SMC Martin Inc.

ORIGINAL (RED)

900 W. Valley Forge Road
P.O. Box 859
Valley Forge, Pennsylvania 19482
Telephone 215 265-2700 or 783-7480

November 2, 1984
Ref: 8713-040-94003

Mr. Michael Apgar
Delaware Division of
Environmental Control
P. O. Box 1401
89 Kings Highway
Dover, DE 19901

Subject: Camdel Metals TCE Spill

Dear Mike:

This letter is to confirm the information provided to the Department of Natural Resources and Environmental Control (DNREC) on October 15, 1984 with respect to a spill of Trichloroethylene (TCE) that occurred at Camdel Metals and the proposed remedial measures that we discussed pursuant to our telephone conversation of October 26, 1984. The cleanup plan describes in detail those steps which Camdel Metals proposes to implement to address any potential environmental harm that may have resulted from the spill.

According to plant personnel, approximately 75 gallons of TCE were spilled onto the plant floor when a pipe providing TCE to the degreaser unit broke while the machine was operating in its automatic cycle. Since then, operating procedures have been revised to provide for immediate shutdown should a similar mechanical failure occur. The TCE traveled in a southwesterly direction to an exterior wall (Figure 2) where it exited the building onto a gravel-covered area adjacent to the building. Based on the amount of TCE recovered in the building, plant personnel involved in the ensuing cleanup indicated that approximately 10 to 15 gallons of TCE escaped to the soil outside. A design study is currently underway to develop an effective in-plant containment system for this area.

Soil sampling, in the area where the TCE exited the building, was conducted on October 16, 1984 to determine the vertical and horizontal extent of TCE contamination. To aid in this determination, a series of soil samples were collected at varying depths using a hand (screw type) auger and analyzed in the field using the Drager tube method. This method employs a modified headspace technique, where volatilization of TCE is induced into the air within a plastic bag. This air is then pumped through TCE-specific colormetric tubes (Drager Inc.) and

a direct reading of TCE concentration is made. This analysis, in conjunction with analytical results obtained from the nearest downgradient well (Well #6, 4,900 ppb), would seem to indicate that TCE has reached the ground water in the area where it exited the building, although the integrity of this well must be evaluated due to its location in the immediate spill area. Given the rate of ground-water movement in this region (approximately .411 ft/day), it is highly unlikely that contamination could have migrated to Well #6, which is located approximately 40 feet from the spill area. Further soil sampling was conducted using the aforementioned method, with results indicating an area of contamination approximately 8 feet x 38 feet (Figure 2). Depths of contamination ranged from five feet (maximum auger depth) adjacent to the spill, to two feet on the outer perimeter.

Camdel Metals has an existing ground-water monitoring network consisting of nine wells and three well points (Figures 2 and 3) to aid in monitoring the extent of a contamination plume that may have resulted from this spill. Four of these wells, which surround the degreaser unit, and the three well points surrounding the TCE storage tank were installed prior to plant operation with EPA concurrence.

We understand that representatives of DNREC have requested that all contaminated soil be removed from the site for disposal in a secure hazardous waste landfill. As you are aware, there are no such facilities located in Delaware or in any of the immediately surrounding states which will mean hauling the contaminated soil to either Ohio or South Carolina. Given Camdel's ability to deal with the contaminated soil on site in an environmentally sound and legally acceptable manner, we have set out below an alternative remedial plan.

1. Remove and aerate contaminated soil via plowing or tilling on plastic sheeting in order to exploit the inherent volatile properties of TCE. After volatilization is complete and the absence of TCE is verified by laboratory analysis, the soil will be spread on site. We believe that this proposal will accomplish all of the environmental objectives of DNREC's suggestions in a more cost-effective manner. More importantly, this plan is not dependent on the performance of third party contractors and does not create the liability associated with off-site disposal remedies. Camdel Metals is prepared to implement its recommended plan upon approval by DNREC.

2. Evaluate the integrity of Well #6, which was sampled and showed TCE contamination. It may be possible that a TCE plume has not spread from the area where it exited the building to this well, but that the TCE spilled inside the building may have migrated down an ineffectively-sealed well casing.

3. Install a recovery well in the spill area and pump the contaminated water to a sprinkler head located on the roof of the building. The runoff will be collected in the existing stormwater collection system and discharged to the sanitary sewer system upon approval by state and county authorities.

4. Perform soil and water sampling to verify the effectiveness of the above remedial measures.

We would appreciate the opportunity to meet with you and discuss the above remedial program prior to any final decision being made.

Sincerely,

SMC MARTIN INC.

(b) (4) [redacted]

Soil Scientist

SJ:rm
Enclosure
8713L1J

cc: Marc Gold, Esquire
Bob Zimmerman
Tom Walsh

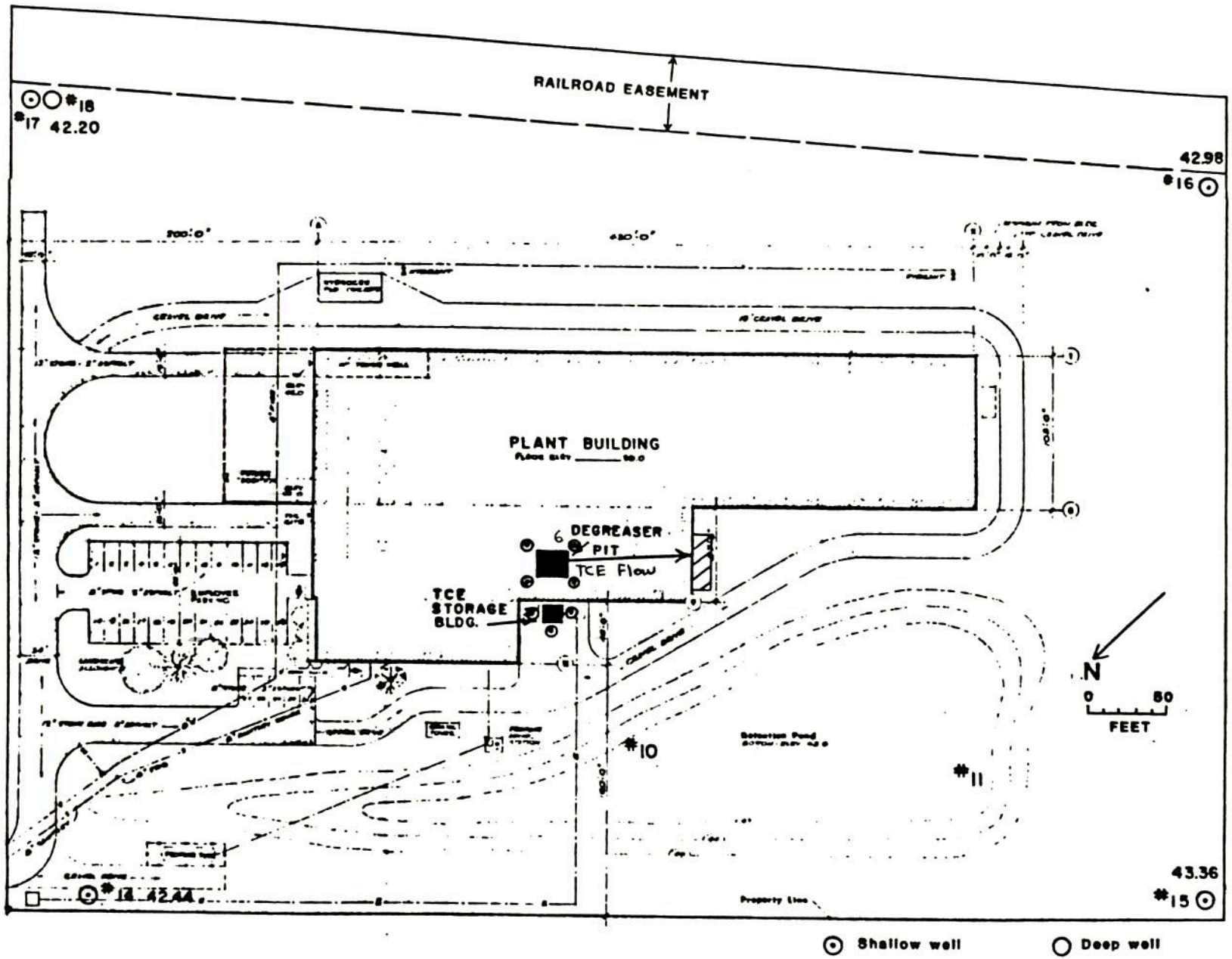

Figure 2. Site Plan

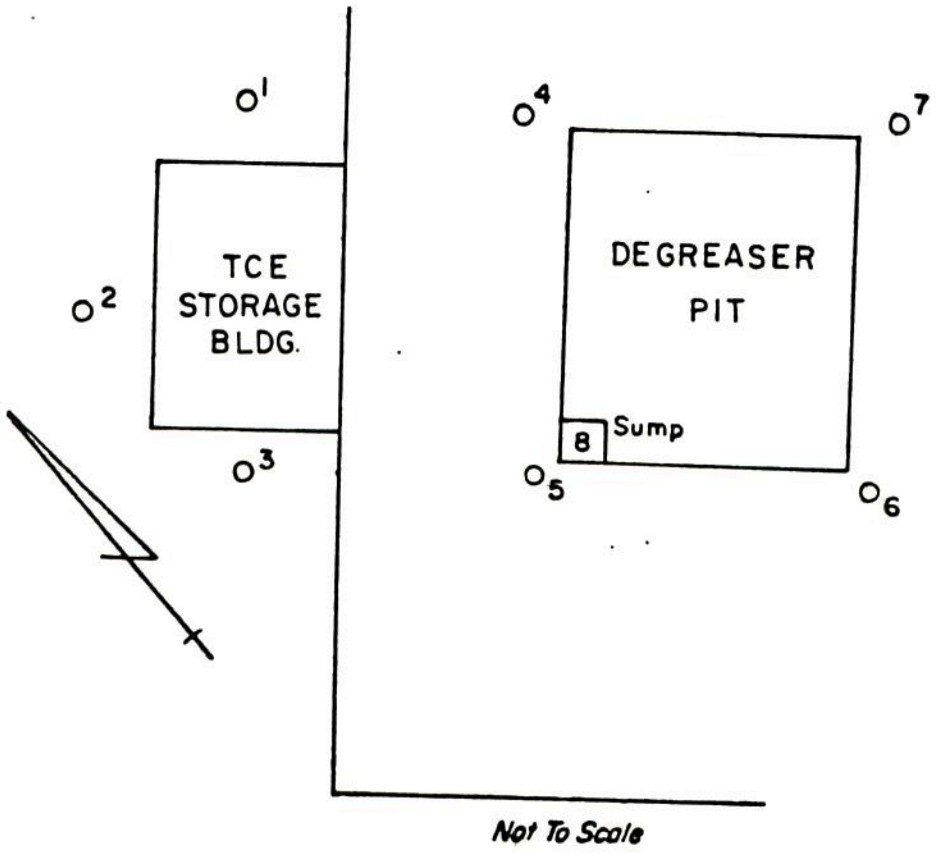

Figure 3. Location of Existing Wells 1-7

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February 1, 1985
Ref: #8713-040-94003

Mr. George Bender
State of Delaware
Department of Natural Resources
and Environmental Control
Solid Waste Section
89 Kings Highway
P. O. Box 1401
Dover, DE 19903

Reference: On-Site Treatment of Trichloroethylene (TCE) Contaminated Soil via Soil Shredding at Camdel Metals

Dear Mr. Bender:

This letter is to provide the Department of Natural Resources and Environmental Control (DNREC) Solid Waste and Water Resources sections with details of the current and proposed clean-up operations performed at Camdel Metals located in Camden, Deleware.

A spill of TCE at this site was previously reported to DNREC in our letter of November 2, 1984. Remedial action regarding the clean-up operation was divided into two phases; Phase I dealt with the on-site treatment of contaminated soils. Phase II will address ground-water concerns.

Treatment methods of the contaminated soil that resulted from this spill were presented to DNREC in our meeting at Camdel Metals on November 19, 1984. Specific details of the treatment method to be used were provided to you in our letter of November 27, 1984. Approval for the treatment method described was granted by DNREC in your phone conversation of November 29, 1984. Due to the inherent difficulties involving availability and mobilization of the soil shredding machine, treatment of the contaminated soils was not begun until December 17, 1984. Treatment continued through December 29, 1984. Treatment of ground-water contamination that may have resulted from this spill will be dependent upon the analytical results obtained from the proposed resampling of recovery well number one (RW-1) which was installed on December 6, 1984.

PHASE I - CLEAN-UP OPERATION - TCE REMOVAL FROM SOILS

Overview of the Soil Shredder Operation

On-site treatment of approximately 200 yds^3 of TCE contaminated soils that resulted from an accidental spill of TCE at Camdel Metals was accomplished by use of a soil shredding machine and front-end loader. The soil shredding machine exploits the natural volatility of TCE by shredding and aerating the soil. This operation thoroughly mixes the soil and produces a more uniform material. Thus, the sampling difficulties often associated with large volumes of material having varying contaminant concentrations is overcome. This shredding and mixing process is more completely described with the diagram in 'Attachment A'.

Sampling Methodology

Two samples per pass through the shredder were collected by placing a five-gallon plastic bucket immediately above the existing waste pile in order to duplicate conditions of the material as it struck the pile. Approximately two gallons of soil were allowed to collect in this manner before the sample was obtained from different portions of each bucket. Immediately after collection, each sample was placed in an iced cooler in order to preserve sample integrity, and logged in the soil scientists' field book. Chain-of-custody forms also accompanied each sample shipment. Samples were delivered to Greenwood Labs on a daily basis to further insure sample integrity and to monitor the concentration of TCE remaining after each pass.

A total of twenty-six samples, representing thirteen passes through the shredder, were obtained in the above described manner. Test results are displayed in the attached graphs (Figures 1-3), with individual sample results presented in Appendix A.

Treatment Results

As you may be aware, current analytical capabilities limit the detection of TCE in soil to approximately 5 parts per billion. Although detection of TCE in soil is possible at these levels, an accurate quantification of an amount that is less than 15 parts per billion is subject to an error of approximately

ATTACHMENT A

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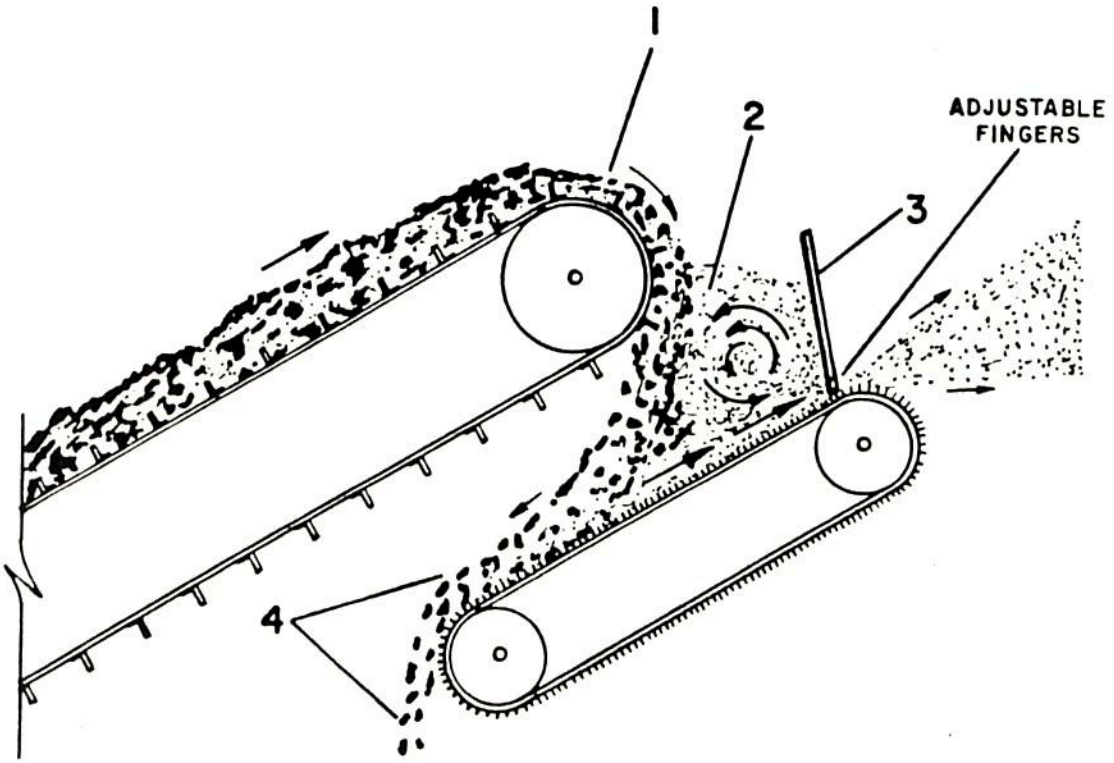

OPERATION (1) Flighted conveyor unloads hopper-delivers soil mix ingredients into shredding belt. (2) High-speed, cleated belt shreds ingredients....aerates and thoroughly mixes with a violent churning, tumbling action. (3) Fully processed mix discharges. Adjustable fingers (variable sweep) permit selection of coarseness of mix discharged. (4) Over-size materials move back for additional processing....sticks, stones and other nonshreddables are rolled back for discharge through trash chute.

FIGURE I
CONCENTRATIONS OF INDIVIDUAL SAMPLES
AFTER EACH PASS (TWO SAMPLES / PASS)

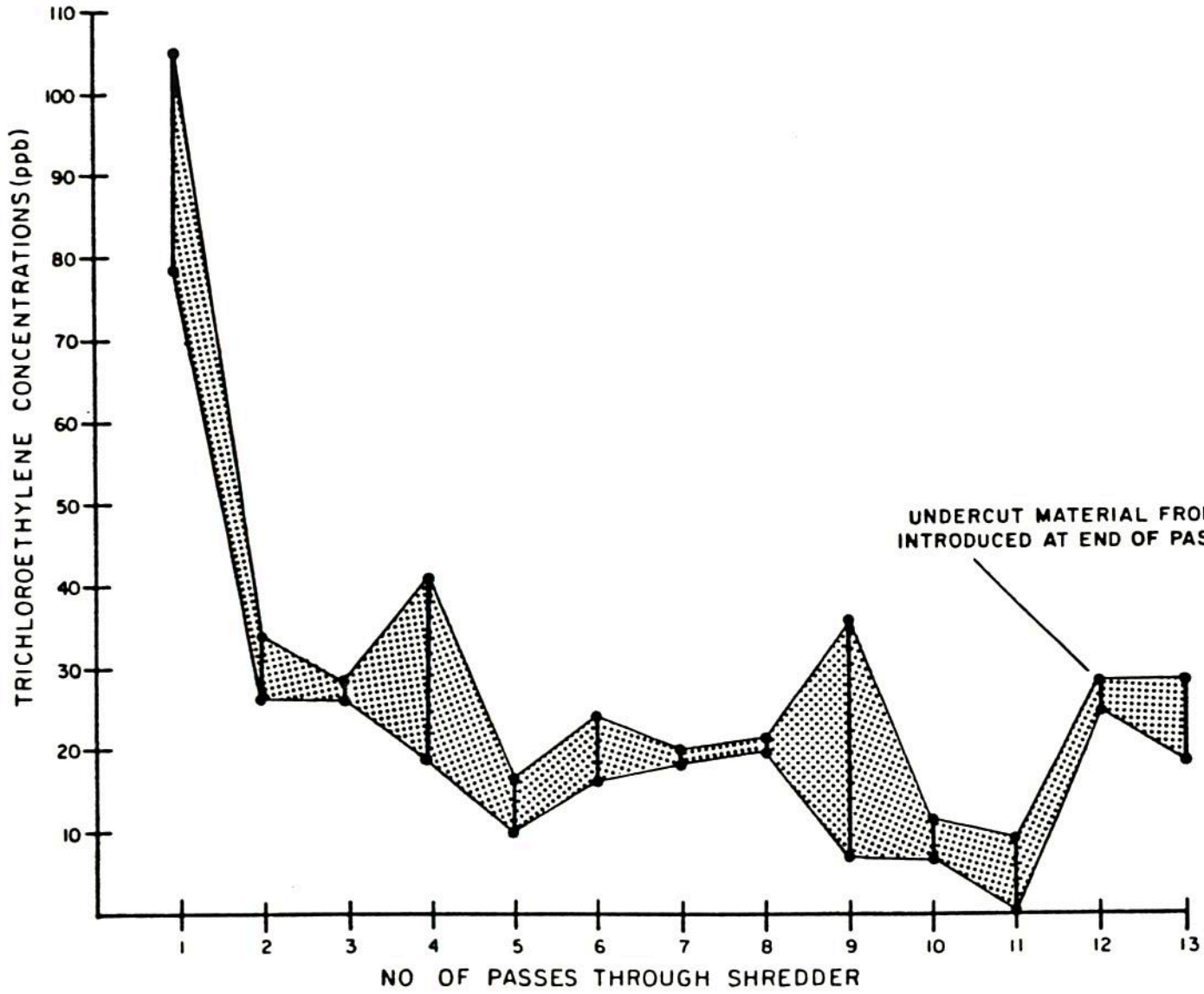

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FIGURE 2
AVERAGE TRICHLOROETHYLENE CONCENTRATIONS
AFTER EACH PASS

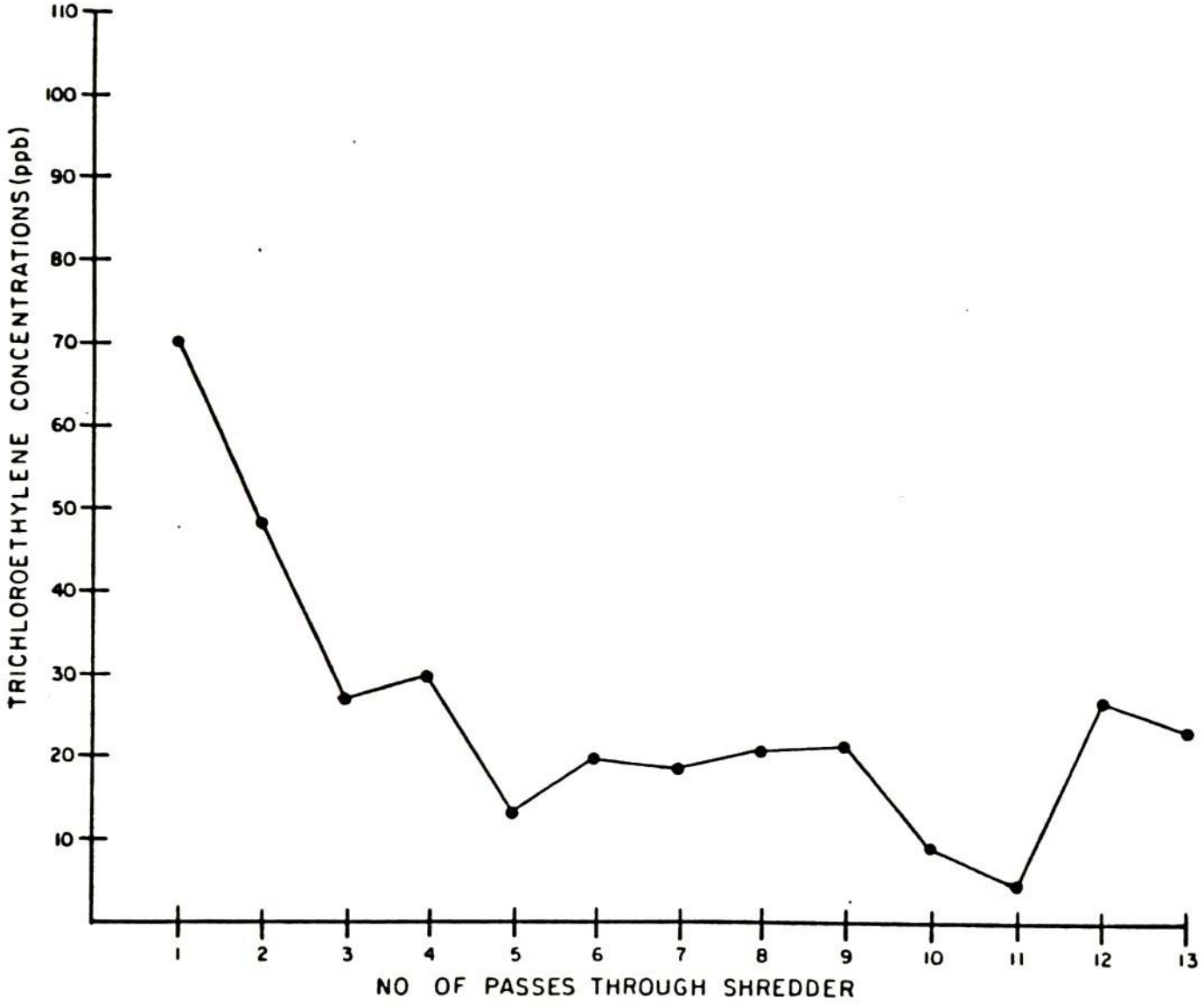

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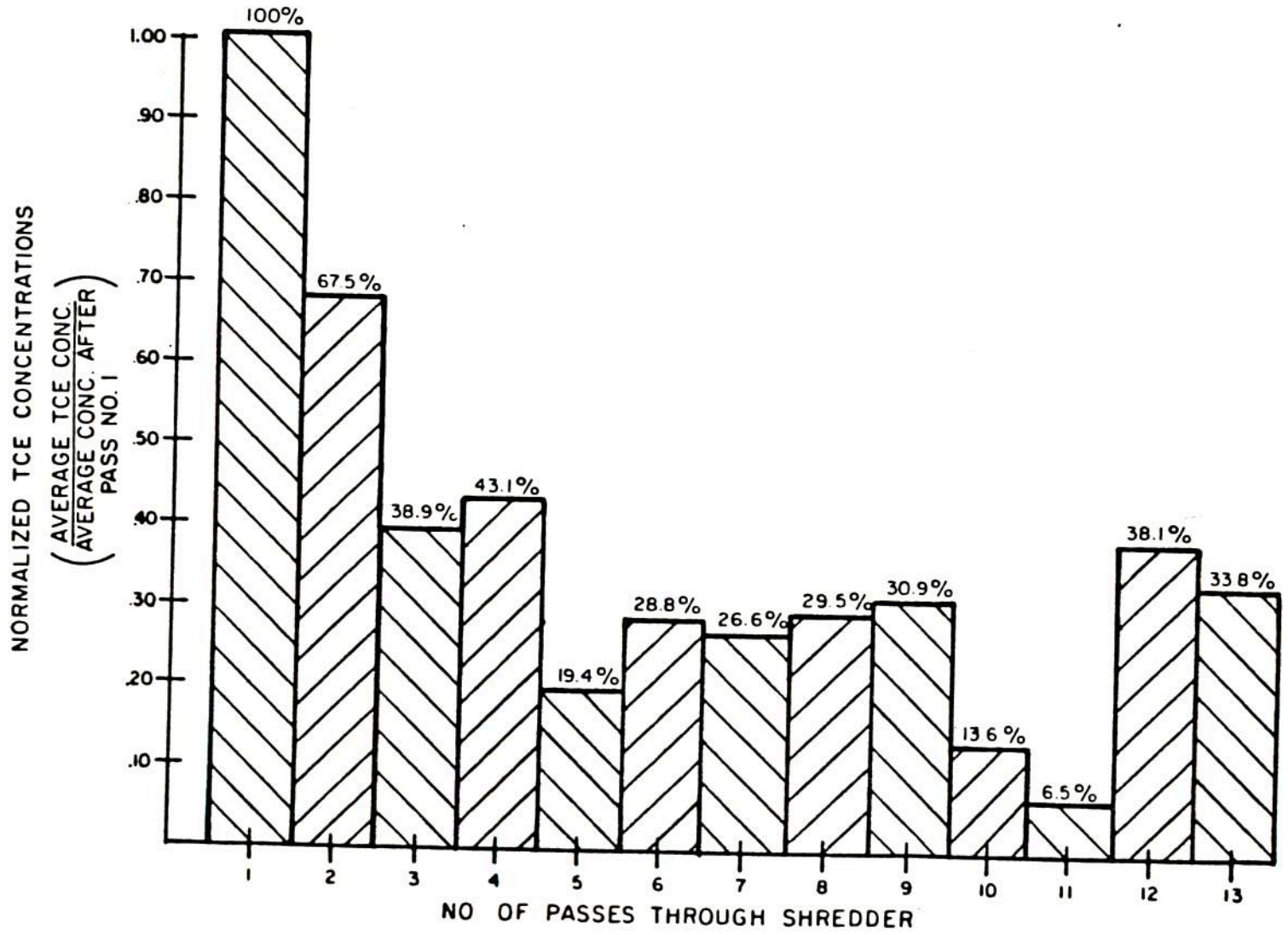
FIGURE 3
NORMALIZED TCE CONCENTRATIONS
(% PRESENT)



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JANUARY 10, 1985

30 percent. A more detailed explanation of the difficulties involved in an accurate quantification of an amount of this size is provided in Appendix B. As shown on Figures 1-3, this range in TCE concentration was achieved by the tenth pass through the shredder. At the request of DNREC, the operational area was undercut from one to three inches to prevent the spread of contamination to the adjacent soil at the end of the eleventh pass. This soil was then placed on the pile of previously treated soil and put back through the shredder for the twelfth and thirteenth passes. The resulting increase in TCE concentrations beginning with the twelfth pass can be attributed to this remedial measure. Given the average TCE concentrations at the end of the shredding operation (23.5 ppb) and the amount of soil in the waste pile, (approximately 200 yds^3), the corresponding amount of TCE will be 0.000966 gallons by volume and 0.01175 pounds by weight, as derived below:

$$\text{Mass of TCE} = \frac{23.5 \times 10^{-9} \text{ gr TCE}}{\text{gr soil}} \times \frac{454 \text{ gr soil}}{\text{lb soil}} \times \frac{2{,}000 \text{ lbs soil}}{\text{ton soil}} \times \frac{1.25 \text{ ton soil}}{\text{yd}^3 \text{ soil}} \times \frac{200 \text{ yd}^3 \text{ soil}}{} \times \frac{\text{lb TCE}}{454 \text{ gr TCE}}$$

$$= 0.01175 \text{ lb TCE}$$

$$\text{Density of TCE} = 91.0 \text{ lb/ft}^3 \text{ [specific gravity of TCE x density of water) = (1.459)(62.4 lb/ft}^3\text{)]}$$

$$\text{Volume of TCE} = \frac{11.75 \text{ lbs TCE} \times \text{ft}^3 \text{ TCE}}{91.0 \text{ lb TCE}} \times \frac{7.481 \text{ gal TCE}}{\text{ft}^3 \text{ TCE}} = 0.000966 \text{ gal of TCE}$$

The resulting reduction of TCE concentration corresponds to 66.2 percent removal at the end of the shredding operation.

Recommendations

The volume of TCE remaining in the soil affected by the spill, as shown above, is less than one thousandth of a gallon. It is Camdel Metals' intent to further reduce the amount of TCE by spreading the soil thinly on-site during suitably dry and warm weather. As we have demonstrated before, this procedure maximizes volatilization and photo decomposition of TCE, and under optimum conditions the TCE concentration will be reduced to below detectable limits (less than ~5 ppb).

Due to the significant reduction in TCE concentrations (about 66.2 percent) accomplished by the soil shredding process, we believe it will be more than adequate to volatilize any remaining TCE by spreading the soil on-site in the above described manner. TCE concentrations will be monitored during the soil spreading operations, which will continue until the TCE concentrations are below detectable limits. DNREC will be kept informed of all monitoring efforts and results.

PHASE II - CLEAN-UP OPERATION - GROUND-WATER CONCERNS

Ground-Water Sampling

Sampling of the recovery well (RW-1) installed in the immediate spill area was conducted on December 28, 1984 using EPA approved methods. Sampling procedures included the purging of three well volumes (approximately 200 gallons) using a stainless steel Grundfos SP1-9 submersible pump with dedicated rope and disposable polythylene tubing. Individual samples were collected using a stainless steel bailer with a dedicated rope. Two samples were obtained from the well. The first sample, RW-1, showed a TCE concentration of 4.3 ppb. A second sample, MW-1, a blind duplicate, was obtained to verify the accuracy of the analysis and showed a TCE concentration of 3.7 ppb (Appendix A).

Recommended Ground-Water Recovery Scenarios

Steve Young of the Department of Natural Resources and Environmental Controls' Water Resources Section has indicated that Monitoring Well RW-1 should be pumped to recover any possible contamination that may have migrated from the spill area. It has been suggested that any possible plume that may have occurred as a result of the spill would have traveled

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approximately forty feet, based on horizontal ground-water velocity of 0.41 feet per day and assuming ninety days since the date of the spill. The total extraction volume required for the recovery of a possible plume from a distance of forty feet would be approximately 302,400 gallons which would be discharged to the nearby stormwater retention basin. TCE concentrations have historically been in the 25-50 ppb range in the area of the degreaser which is located approximately thirty-five feet northeast of the recovery well. TCE concentrations resulting from the above mentioned amount of pumping found to contain less than those historically present would not be representative of a contamination plume resulting from the spill, but rather a result of previously existing contamination. Ground-water monitoring will continue in the previously approved manner if contaminant concentrations prove to be equal to or less than those already present in the degreaser area. Various recovery time scenarios are presented in Attachment B.

Upon your approval, we will implement one of the scenarios proposed in Attachment B in order to recover any possible contamination plume that may have resulted from the spill. Pumping rates and times will be adjusted in order to accommodate the actual travel time of a possible contamination plume.

If you should have any questions or comments concerning the above report, please do not hesitate to contact us.

Very truly yours,

SMC MARTIN INC.

(b) (4) [redacted]

Soils Scientist

SEJ/bf
Enclosure
8713L1

cc: T. Walsh
R. Zimmermann
M. Gold
M. Apgar
S. Young

ATTACHMENT B .

RECOVERY PROGRAM DESIGN

Plume Migration (based on ground-water flow)

$$D = V_w(t)$$

where

D = distance of plume migration from spill site (ft)
V_w = horizontal ground-water velocity (ft/day) (from report)
t = time in days since spill

D = 0.41 (90) = 36.9 ft
= ~40 ft

Recovery Time Scenarios

Q = pumping rates (gpm)
i = ground-water gradients to pumping well
V = ground-water velocity under pumping conditions
T_t = travel time of plume to pumping well

Recovery rates based on 1-day pumping velocities

1. Q = 50 gpm
i = 0.032
V = 9.14 ft/day
T_t = 4.4 days

2. Q = 75 gpm
i = 0.049
V = 14 ft/day
T_t = 2.9 days

3. Q = 100 gpm
i = 0.066
V = 18.86 ft/day
T_t = 2.1 days

4. Q = 150 gpm
i = 0.102
V = 29.14 ft/day
T_t = 1.4 days

Total Extraction Volume - All Scenarios

302,400 gallons

APPENDIX A

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

ORIGINAL (RED)

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4), Ph.D.

DATE: December 19, 1984 GREENWOOD NO. GL 6478

SUBJECT: Examination of soil samples for trichloroethylene and related compounds.

SAMPLES: GL 6478-1 thru -6: Camdel Metals Corporation

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure for similar samples. The analytical areults are as follows:

GL # 6478-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	12/17/84 1st Bucket Before 1:30 pm	19 ηg/g	0	0	0
2	" 1st Bucket After 1:35 pm	34 ηg/g	0	0	0
3	" 1st Pass #1 2:45 pm	105ηg/g	0	0	0
4	" 1st Pass #2 3:30 pm	78 ηg/g	0	0	0
5	" Random Before(1st pass)3:45 pm	64 ηg/g	0	0	0
6	" Random After(1st pass)3:52 pm	54 ηg/g	0	0	0

(b) (4)

(b) (4), Ph.D.
GREENWOOD LABORATORIES

GRU:del
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Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4), Ph.D.

DATE: December 20, 1984 GREENWOOD NO. GL 6481

SUBJECT: Examination of soil samples for trichloroethylene and related compounds.

SAMPLES: GL 6481-1 thru -3: Camdel Metals Corporation (listed below).

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6481-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	2nd Pass #1 12/18/84 2:40 pm	34 ng/g	0	0	0
2	Before 2nd Pass " 3:25 pm	77 ng/g	0	0	0
3	After 2nd Pass " 3:28 pm	81 ng/g	0	0	0

Note: ng/g = ppb w/w

(b) (4)

(b) (4) Ph.D.
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GRU:del
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ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

TO: (b) (4)
SMC Martin
P.O. Box 859
Valley Forge, PA 19482

FROM: (b) (4), Ph.D.

DATE: December 21, 1984 GREENWOOD NO. GL 6484

SUBJECT: Examination of soil samples for trichloroethylene and related compounds.

SAMPLES:
GL 6484-1: 2nd Pass #2 12/20/84 9:10 a.m.
GL 6484-2: 3rd Pass #1 " 12:50 pm
GL 6484-3: 3rd Pass #2 " 1:30 pm
GL 6484-4: 4th Pass #1 " 3:45 pm

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

Sample Identity	Trichloroethylene (C_2HCL_3)
2ND Pass #2	26 ηg/g
3rd Pass #1	26 ηg/g
3rd Pass #2	28 ηg/g
4th Pass #1	41 ηg/g

No other components were detected in these samples.

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(b) (4), Ph.D.
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Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

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TO: (b) (4)
SMC Martin
P.O. Box 859
Valley Forge, PA 19482

FROM: (b) (4), Ph.d.

DATE: December 27, 1984 GREENWOOD N'. GL 6485

SUBJECT: Examination of soil samples for trichloroethylene and related compounds.

SAMPLES: GL 6485-1: 4th Pass #2 12/20/84 5:50 pm
GL 6485-2: 5th Pass #1 9:30 a.m. 12/21/84

SUMMARY:

These two samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

SAMPLE IDENTITY	TRICHLOROETHYLENE
4th Pass #2	19 ng/gram
5th Pass #1	10 ng/gram

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903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

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TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4), Ph.D.

DATE: December 31, 1984 GREENWOOD NO. GL 6489

SUBJECT: Examination of soil samples for trichloroethylene and related compounds.

SAMPLES: GL 6489-1 thru -3: Camdel Metals (listed below).

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6489-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	5th Pass #2 12/16/84 10:50 pm	17 ng/g	0	0	0
2	6th Pass #1 " 2:10 pm	24 ng/g	0	0	0
3	6th Pass #2 " 3:25 pm	16 ng/g	0	0	0

(b) (4)

(b) (4), Ph.D.
GREENWOOD LABORATORIES

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Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7292

TO: (b) (4)
SMC Martin
P.O. Box 859
Valley Forge, PA 19482

FROM: (b) (4), Ph.D.

DATE: December 31, 1984

GREENWOOD NO. GL 6491

SUBJECT: Examination of soil samples for trichloroethylene and related compounds.

SAMPLES: GL 6491-1 thru -4: Camdel Metals (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedures. The analytical results are as follows:

GL # 6491-	Sample Identity			C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	7th Pass #1	12/26/84	5:05 pm	17 ng/g	0	0	0
2	7th Pass #2	"	9:50 am	20 ng/g	0	0	0
3	8th Pass #1	"	12:00 noon	19 ng/g	0	0	0
4	8th Pass #2	"	1:50 pm	21 ng/g	0	0	0

(b) (4)

(b) (4), Ph.D.
GREENWOOD LABORATORIES

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Copy: R. Zimmerman, Handy & Harman Tube Co.; M. V. Vaughn, Camdel Metals Corp.

Greenwood Laboratories

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ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4), Ph.D.

DATE: January 4, 1985 GREENWOOD NO. GL 6495

SUBJECT: Examination of soil and water samples for trichloroethylene and related compounds.

SAMPLES: GL 6495-1 thru -8: Camdel Metals Corp. (listed below)

SUMMARY:

These samples have been examined by gas chromatography with electron capture detection, using the previously described methods for soil and water samples. The analytical results are as follows:

GL 6495-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	12/27/84 9th Pass #1 3:45 am (soil)	7 ng/g	0	0	0
2	" 9th Pass #2 4:35 am "	36 ng/g	0	0	0
3	12/28/84 10th Pass #1 9:05 am "	7 ng/g	0	0	0
4	" 10th Pass #2 11:10 am "	12 ng/g	0	0	0
5	" 11th Pass #1 1:40 pm "	9 ng/g	0	0	0
6	" 11th Pass #2 3:52 pm "	0	0	0	0
7	" RW-1 5:45 pm (water)	4.3 ug/L	0	0	1.6ug/L
8	" MW-1 6:00 pm (water)	3.7 ug/L	0	0	1.4 ug/L

(b) (4)

(b) (4), Ph.D.
GREENWOOD LABORATORIES

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copy: R. Zimmerman, Handy & Harman Tube co.; Millard V. Vaughn, Camdel Metals

Greenwood Laboratories

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ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4), Ph.D.

DATE: January 4, 1985 GREENWOOD NO. GL 6496

SUBJECT: Examination of soil samples for trichloroethylene and related compounds.

SAMPLES: GL 6496-1 thru - 5: Camdel Metals Corp. (listed below)

SUMMARY:

These samples have been examined by gas chromatography with electron capture detection using the previously described procedure. The analytical results are as follows:

GL # 6496-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	12/19/84 12th Pass #1 9:15 am	28 ng/g	0	0	0
2	" 12th Pass #2 9:50 am	25 ng/g	0	0	0
3	" 13th Pass Powder 11:35 am	32 ng/g	0	0	0
4	" 13th Pass #1 12:00 n	28 ng/g	0	0	0
5	" 13th Pass #2 1:50 pm	19 ng/g	0	0	0

(b) (4)

(b) (4), Ph.D.
GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman Tube Co.; Millard V. Vaughn, Camdel Metals

APPENDIX B

ORIGINAL (RED)

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

January 4, 1985

Steven Johnson
SMC Martin
P.O. Box 859
Valley Forge, PA 19482

Dear Steve:

This letter will be an attempt to respond to our telephone conversation this morning regarding accuracy and lower limits of detection, specifically in the analytical measurements applied to the series of soil samples most recently from Camdel Metals Corporation.

To assist me in the discussion, which I will try to make brief, I am including copies of a document in publication which paraphrases parts of a paper from Analytical Chemistry, i.e. ACS Committee on Environmental Improvements, "Principles of Environmental Analysis,", Anal. Chem., 55, 2210-2218 (1983).

To help you recognize the nature of our problem with these samples, I am including copies of chromatograms which hopefully will illustrate the nature of the analytical problem. You will note, on these chromatograms there is an analog chart and also computations. Our normal practice is to use the computed values which are determined from a prior calibration of the system with standards of known composition. This method of measurement is applied to extracts either from water or from soils. However, in the case of water samples, the extract is a 10-fold concentration from the original sample, while with soil samples the extract is only a 2-fold concentration. The calibration values actually pertain to the extract solution which is measured. For water analyses then, the computed value is divided by 10. In the case of soil samples, it is only divided by 2. Therefore, a stated minimum detectable concentration from a water sample, relative to that sample, is approximately 1 ppb The corresponding circumstance in the case of soil samples means that minimum is approximately 5 ppb. In either case, however, the actual computer readout would be 10 ppb. For the computer to sense the peak which corresponds to the component of concern requires first a specified minimal area and second, a specified minimum rate of change of the analog signal at the points where the signal for that component starts and ends. A consequence of this is that there are circumstances at or near the minimum detectable level in which the computer fails to recognize the component peak, even though visually we can recognize its presence. When this happens, we make an estimation of the amount present, based upon the height of the peak which the computer missed relative to the height of the smallest peak which the computer, in fact, detected.

These items are pointed out in copies of 2 chromatograms. One shows a calculated quantity and the second shows an uncalculated quantity which is obviously still recognizable on the analog chart or graph. This means that at or near the

Steven Johnson
SMC Martin

January 4, 1985

minimum detectable level, specifically in the case of soil samples, a given value, such as 5 or 7 ng/g (ppb) may in fact be a value anywhere from one-half to twice that amount. When the computer detects the component, the error still may range by 30% around the computed value. This is simply because of the limited ability to detect the precise moment in time when the signal departs from a baseline and again returns to it. To further assist in understanding this, I am also including a chromatogram of a standard where it is clearly more obvious how sharply the baseline changes when a significant quantity of component reaches the detector and also when it leaves.

To put this perhaps in a slightly more practical framework: there is some concern in the case of drinking water for concentrations down to the range of a few parts per billion (one value given us is 3.5). This is because people are ingesting significant volumes of water over a long period of time. On the other hand, ppb levels in soil, such as we are dealing with in this case, after your treatment of the soil, are so low as to be highly unlikely to constitute any hazard since (a) the material is not being consumed directly by people and, (b) what remains after the very significant treatment you have given the soil is likely to be rather tightly adsorbed and consequently released slowly over a long period of time in concentrations which will then be essentially undetectable, even with the magnificent sensitivity levels available with current analytical instruments.

Sincerely yours,

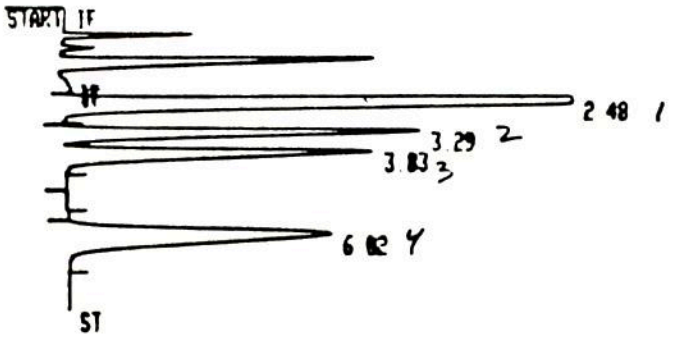
Gerald R. Umbreit

Gerald R. Umbreit, Ph.D.
GREENWOOD LABORATORIES

GRU:del
Enclosures

MUL FACTOR= 1.0000E+00

ID 6495-1000 = Standard



RUN # 292 JAN/02/85 16:02:15
ID 6495-100

ESTD

	RT	AREA	TYPE	CAL#	AMOUNT - ppb
1	2.48	208540	BR	1	1366.500
2	3.29	67815	BV	2	1500.100
3	3.83	72880	VB	3R	1501.600
4	6.02	97295	BB	4R	160.870

CH_3CCl_3 - 1
$CHCl_3$ — 2
TCE — 3
PCE — 4

TOTAL AREA= 446530
MUL FACTOR= 1.0000E+00

true values (within limits of preparation accuracy) are
1 1350
2 1500
3 1500
4 160

RCALB @
ESTD CALIB RUNS 2
REF % RTW -0.25 % RTW 5.00

CAL#	RT	AMT	AMT/AREA
1	2.50	1.3500E+03	6.5131E-03
2	3.32	1.5000E+03	2.2120E-02
3R	3.84	1.5000E+03	2.0593E-02
4R	6.05	1.6900E+02	1.6489E-03

ID 6495-0 @ — = Blank

START IF

IF - integrator sees nothing! (computer)

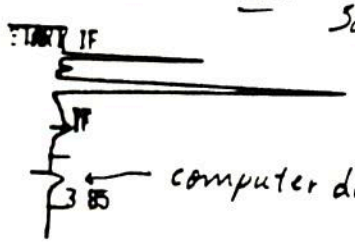
STOP

RUN # 293 JAN/02/85 16:11:16
ID 6495-0
NO RUN PEAKS STORED

ID 6495-1 @

START IF

ID 6495-2@ Sample #2



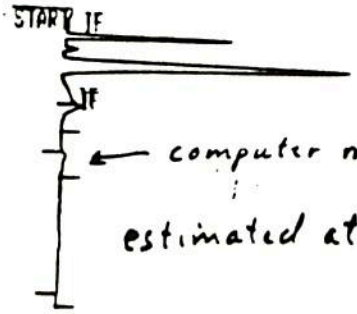
RUN # 295
ID 6495-2 JAN/02/85 16:23:28

ESTD RT	AREA	TYPE	CAL #	AMOUNT
3.85	3481	BB	3R	71.685

TOTAL AREA= 3481
MUL FACTOR= 1.0000E+00

$\frac{71.685}{2}$ = 36 ng/g in soil sample

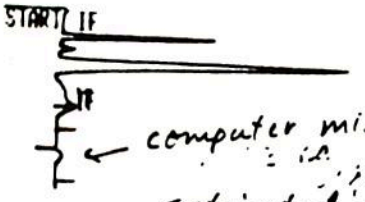
ID 6495-3@



estimated at $\frac{14}{2}$ = 7 ng/g in soil sample

RUN # 296
ID 6495-3 JAN/02/85 16:29:38
NO RUN PEAKS STORED

ID 6495-4@



Estimated at $\frac{24}{2}$ = 12 ng/g in soil sample

RUN # 297
ID 6495-4 JAN/02/85 16:38:05
NO RUN PEAKS STORED

SMC Martin Inc.
8713REF/1

January 11, 1985
Ref: #8713-040-94003

1. When measurements are made of components at or near the detection limit, a certain number of analyses can be expected to be zero. As a consequent of this point, and the range of variability commonly encountered in trace level measurements, data points should not be omitted when evaluating a set of data. The only basis for deleting items of data will be the analyst's observation of a specific error or a mistake or malfunction occurring in the processing or analysis of a sample. Since most of these observations will come before the analysis is complete, that particular analysis should actually be discarded before a final analytical value is obtained. However, if it is in the chromatographic analysis step, the system normally will carry through the analysis to provide a record. This record should be marked with the analyst's observation of a malfunction or error and that data deleted from consideration whether or not it appears to conform with the balance of the analytical data.

2. ....because the computer or calculator provides 4, 5 or 6 digits does not imply that those are significant numbers. For example, reporting the concentration of a pollutant in water at 3.082 ug/L is obviously unrealistic. Most analyses at this concentration level will likely be accurate only to one significant figure. A computer report which indicates such a value might logically be rounded by the intelligent analytical chemist to 3 ug/L for his report. It is important that an analytical report not imply limits of accuracy better than can be defended by statistical means. It is of significant importance that the accuracy limits or the range of variation of any given analysis be stated with the report. Without this, persons untrained in science, but having a responsibility in regulatory or legal actions, may easily interpret the value of 3.082 as a numerically exceeding a limit specified as 3.0.

REFERENCE 2F

SMC Martin
A Division of Science Management Corporation
900 W. Valley Forge Road
P.O. Box 859
Valley Forge, Pennsylvania 19482
Telephone 215 265-2700

ORIGINAL
(RED)

April 23, 1985
Ref: 8713-040-94004

Mr. Randy McAlister
Department of Natural Resources
& Environmental Control
Water Resources Section
89 Kings Highway
P. O. Box 1401
Dover, DE 19903

Dear Randy:

I have enclosed a copy of the Camdel Metals Ground-Water Recovery project chemical results for April 18, 19, 1985. I will keep you informed on our progress and additional analytical results when available.

Sincerely,

SMC MARTIN INC.

(b) (4) [redacted]

Hydrogeologist

GJB:rm
Enclosure
8713L1J

RECEIVED
APR 24 1985
WATER SUPPLY BRANCH

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

ORIGINAL (RED)

TO: (b) (4)
SMC MARTIN
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: April 22, 1985 GREENWOOD NOS. GL 6594 & 6597

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6594-1 thru -6: Camdel Metals (rec'd 4/18/85)
GL 6597-1 thru -3: Camdel Metals (rec'd 4/19/85)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6594-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	1Z Pond 4/18/85 12:00	0	0	0	0
2	2 RW-1 " 14:38	~1 ug/L	0	0	1.1 ug
3	2 Pond ~~Ground Water~~ 4/18 14:41	0	0	0	0
4	1 MW 19 4/18/85 11:35	~1 ug/L	2.0 ug	0	0
5	1 RW-1 " 12:35	~2 ug/L	3.4 ug	0	1.8 ug
6	1 S-P Interface 4/18/85 14:40	0	0	0	0
GL # 6597-					
1	3 W RW-1 4/19/85 8:05	~1 ug/L	0	0	1.0 ug
2	2 SP Spray-Pond Interface 4/19/85	0	0	0	0
3	3P Pond 4/19/85 8:10	0	0	0	0

Trichloroethylene — 1,1,1-Trichloroethane — Tetrachloroethylene

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman Tube co.; Millard V. Vaughn, Camdel Metals

SMC Martin
A Division of Science Management Corporation
900 W. Valley Forge Road
P.O. Box 859
Valley Forge, Pennsylvania 19482
Telephone 215 265-2700

ORIGINAL (RED)

per 5/9/85 File

May 7, 1985
Ref: #8713-040-94004

Mr. Randy McAlister
Department of Environmental Resources
and Environmental Control
Water Resources Section
89 Kings Highway
P.O. Box 1401
Dover, DE 19903

Dear Mr. McAlister:

Enclosed please find copies of the current analyses regarding the groundwater recovery project being conducted at Camdel Metals located in Camden, Delaware. The recovery program was initiated on April 18, 1985. 1,099,600 gallons have been recovered and treated as of May 1, 1985. Sampling frequencies for the recovery well and spray interfaces, as well as the pond and monitor well nineteen have been daily for the first eleven days, 4/18 - 4/28, followed by tri-weekly sampling for the week of 4/29 - 5/3. Bi-weekly sampling will be conducted for the remainder of the recovery program. I will continue to forward analytical results to you as they become available. If you have any questions or concerns, please don't hesitate to call.

Sincerely,

(b) (4) [redacted]

Soil Scientist

SJ:njs
Enclosure
8713L1N

RECEIVED
MAY 9 1985
WATER SUPPLY BRANCH

Greenwood Laboratories

ORIGINAL (RED)

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

TO: (b) (4)

SMC MARTIN
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: April 24, 1985 GREENWOOD NO. GL 6600

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6600-1 thru -9: Camdel Metals (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL #-6600-	Sample Identity			C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	4 SP	4/20/85	6:40 pm S-P Interface	7.1 ug/L	0	0	0
2	3 SP	4/20/85	8:00 pm S-P Interface	32 ug/L	0	0	0
3	4 P	"	8:00 pm Pond	0	0	0	0
4	4 W	"	8:00 pm RW-1	21 ug/L	0	0	0.8 ug/L
5	5 P	4/21/85	5:40 pm Pond	7.8 ug/L	0	0	0
6	5 W	"	5:40 pm RW-1	13 ug/L	0	0	0.7 ug/L
7	6 P	4/22/85	12:50 pm Pond	0	0	0	0
8	6 W	"	12:46 pm RW-1	4.6 ug/L	0	0	0.8 ug/L
9	5 SP	"	12:55 S-P Interface	~2 ug/L	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman; Millard V. Vaughn, Camdel Metals

Greenwood Laboratories

ORIGINAL (RED)

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: April 29, 1985 GREENWOOD NO. GL 6603 & 6605

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6603-1 thru -9: Camdel Metals (rec'd 4/25/85 - listed below)
GL 6605-1 thru -5: Camdel Metals (rec'd 4/26/85 - " ")

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6603-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	7 W RW-1 4/23/85 17:45	6.7 ug/L	0	0	0.7 ug/L
2	6 SP Spray-Pond INterface 17:45 4/23	0	0	0	0
3	7 P Pond 4/23/85 17:45	5 ug/L	0	0	0
4	8 W RW-1 4/24/85 13:20	16 ug/L	0	0	0.7 ug/L
5	7 SP Spray Pond 4/24/85 13:35	24 ug/L	0	0	0
6	8 P Pond 4/24/85 13:30	10 ug/L	0	0	0
7	Well 4 4/24/85 13:48	9.2 ug/L	0	0	0
8	Well 4A " 13:48	9.0 ug/L	0	0	0
9	Well 7 " 14:35	10 ug/L	0	0	0
GL # 6605-					
1	S-1 Spray 4/25/85 6:50 pm	~2 ug/L	0	0	0
2	9 RW-1 Recovery Well 4/25 6 pm	67 ug/L	0	0	0.6 ug/L
3	S-2 Spray 4/26/85 10:30-10:45 pm	5.3 ug/L	0	0	0
4	10 RW-1 Recovery Well 4/26/85 10:04 am	120 ug/L	0	0	0.8 ug/L
5	2 W 19 Well 19 4/26/85 10:29 am	0	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman; M. V. Vaughn, Camdel Metals

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

ORIGINAL (RED)

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: May 1, 1985 GREENWOOD NO. GL 6607

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6607-1 thru -4: Camdel Metals (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6607-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	Water sample Recovery Well 4/27/84 8:15 am	160 ug/L	0	0	0.9 ug/L
2	Water from Ground Spray " 9:50 am	8.1 ug/L	0	0	0
3	12 RW1 (CW) 4/29/85 2:40 pm	190 ug/L	0	0	1.0 ug/L
4	Lawn Spray #4 (GW) 4/29/85 2:53 pm	13 ug/L	0	0	0

(b) (4)
GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman; Millard V. Vaughn, Camdel Metals Corp.

SMC Martin
A Division of Science Management Corporation
900 W. Valley Forge Road
P.O. Box 859
Valley Forge, Pennsylvania 19482
Telephone 215 265-2700

RM 6/18/85

ORIGINAL (RED)

June 14, 1985
Ref: 8713-040-94003

RECEIVED

JUN 17 1985

WATER SUPPLY BRANCH

Mr. Randy McAlister
Department of Environmental Resources
& Environmental Control
Water Resources Section
89 Kings Highway
P. O. Box 1401
Dover, DE 19903

Dear Mr. McAlister:

Enclosed please find copies of the analyses regarding the ground-water recovery program currently being conducted at Camdel Metals located in Camden, Delaware. As of June 11, 1985, 4,150,000 gallons have been recovered and treated. Sampling frequencies for the recovery well and spray interfaces, as well as the pond and Monitor Well 19, located downgradient from the ground spray area, have been biweekly since May 3, 1985. Contaminant concentrations from the recovery well have decreased from a high of 190 ppb Trichloroethylene (TCE), April 29, 1985 to a current level of 47 ppb TCE as of June 7, 1985. Biweekly sampling will continue for the remainder of the recovery program. As referenced in your letter of March 28, 1985, we will terminate the recovery program when contaminant levels have stabilized in the 25-50 ppb range. I will continue to forward analytical results as they become available.

If you have any questions or concerns, please do not hesitate to call.

Sincerely,

SMC MARTIN INC.

(b) (4) [redacted]

Soil Scientist

SEJ:rm
8713LJ1

cc: Tom Walsh
Bob Zimmerman

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

ORIGINAL (RED)

TO: (b) (4)
SMC MARTIN
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: May 9, 1985 GREENWOOD NO. 6618

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6618-1 thru -3: Camdel Metals (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6618-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1-5-7 Recovery Well-1	110 ug/L	0	0	1.2 ug/L
2	Spray 5-7 Lawn Spray Interface	5.4 ug/L	0	0	0
3	MW-19-5-7 MW19	0	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
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Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

ORIGINAL (RED)

TO: (b) (4)
SMC MARTIN
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: May 15, 1985 GREENWOOD NO GL 6622

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6622-1 thru -4: Camdel Metals (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6622-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1 5/10/85	91 ug/L	0	0	1.4 ug/L
2	Ground Spray 5/10/85	4.6 ug/L	0	0	0
3	Pond 5/10/85	0	0	0	0
4	MW-19 5/10/85	0	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman; M.V. Vaughn, Camdel Metals

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

ORIGINAL (RED)

TO: (b) (4)
SMC MARTIN
P O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: May 15, 1985 GREENWOOD NO. GL 6625

SUBJECT: Examination of water samples for trichloroethylene and related compounds

SAMPLES: GL 6625-1 thru -4: Camdel Metals (listed below).

SUMMARY

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6625-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	5/14/85 RW-1	100 ug/L	0	0	1.5 ug/L
2	" Ground Spray	35 ug/L	0	0	0
3	" Pond	0	0	0	0
4	" MW-19	0	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman; Millard Vaughn, Camdel Metals

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

ORIGINAL (RED)

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: May 22, 1985 GREENWOOD NO GL 6630

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6630-1 thru -6: Camdel Metals

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6630-	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	5/20/85	RW-1 12:05 pm	75 ug/L	0	0	1.6ug/L
2	"	Ground Spray 12:05 pm	~2 ug/L	0	0	0
3	"	Pond 12:15 pm	0	0	0	0
4	"	MW-19 1:05 pm	0	0	0	0
5	5/17/85	Ground Spray	16 ug/L	0	0	0
6	"	Pond	14 ug/L	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman; Millard Vaughn, Camdel Metals Corp.

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

ORIGINAL (RED)

TO: (b) (4)
SMc Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: May 28, 1985 GREENWOOD NO. GL 6633

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6633-1 through -4: Camdel Metals (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6633-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1 5/24/85 11:15 pm	67 ug/L	0	0	2.3 ug/L
2	Ground Spray 5/24 11:20 pm	~1 ug/L	0	0	0
3	Pond 5/24 11:25 pm	6.5 ug/L	0	0	0
4	MW-19 5/24 11:34 pm	0	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman; Millard Vaughn, Camdel Metals

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

ORIGINAL (RED)

TO: (b) (4)

SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: May 31, 1985 GREENWOOD NO. GL 6636

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6636-1 thru -4: Camdel Metals (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6636-	Sample Identity			C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1	5/28/85	2:07 pm	65 ug/L	0	0	1.7 ug/L
2	Ground Spray	"	2;10 pm	4.5 ug/L	0	0	0
3	MW-19	"	2:55 pm,	0	0	0	0
4	Pond	"	2:00 pm	0	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman Tube Co.; Millard Vaughn, Camdel Metals

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

ORIGINAL (RED)

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: June 4, 1985 GREENWOOD NO. GL 6640

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6640-1 thru -6: Camdel Metals (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6640-	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1	5/31/85 1:15 pm	64 ug/L	0	0	1.2 ug/L
2	Ground Spray	" 1:20 pm	0	0	0	0
3	Pond	" 1:10 pm	0	0	0	0
4	MW-19	" 2:05 pm	0	0	0	0
5	MW-14	" 2:30 pm	0	0	0	0
6	MW-15	" 2:20 pm	0	0	0	0

(b) (4)
GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman; M. V. Vaughn, Camdel Metals Corp.

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

ORIGINAL (RED)

TO: (b) (4)
SMC MARTIN
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: June 5, 1985 GREENWOOD NO. GL 6443

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6443-1 thru -4: Camdel Metals (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6443-	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1-6/4	Recovery Well #1	78 ug/L	0	0	1.6 ug/L
2	FS-6/4	Field Spray	0	0	0	0
3	P-6/4	Pond	8.2 ug/L	0	0	0
4	MW-19-6/4	Monitor WEll #19	0	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman Tube Co.; Millard Vaughn, Camdel Metals

ORIGINAL
(RED)

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: June 11, 1985 GREENWOOD NO. GL 6647

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6647-1 thru -4: Camdel Metals (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously des cribed procedure. The analytical results are as follows:

GL # 6647-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1-6/7 12:38 pm	47 ug/L	0	0	1.7 ug/L
2	Pond 6/7 12:48 pm	9.0 ug/L	0	0	0
3	SP-6/7 Spray Field 12:43 pm	0	0	0	0
4	MW-19-6/7 2:00 pm	0	0	0	0

(b) (4)
GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman Tube Co.; Millard Vaughn, Camdel Metals Corp.

SMC Martin
A Division of Science Management Corporation
900 W Valley Forge Road
PO Box 859
Valley Forge, Pennsylvania 19482
Telephone 215 265-2700

ORIGINAL
(RED)

July 19, 1985
Ref: 8713-040-94003

Mr. Randy McAlister
Department of Environmental Resources
and Environmental Control
Water Resources Section
89 Kings Highway
P.O. Box 1401
Dover, DE 19903

Dear Mr. McAlister:

Enclosed please find copies of the analyses regarding the groundwater recovery program being conducted at Camdel Metals. As of July 16, 1985, 6,933,000 gallons have been recovered and treated. Contaminant concentrations from the recovery well have remained below 50 ppb since June 28, 1985. We are proposing to terminate the recovery program as of July 30, 1985 should contaminant concentrations remain stabilized below 50 ppb. In the event that contaminant concentrations do not remain stabilized below 50 ppb, the recovery program will continue until the desired stabilized concentrations are achieved. I will continue to forward analytical results, regarding the recovery program, for the remainder of the month or until stable conditions are achieved.

If you have any questions or concerns, please do not hesitate to contact me.

Sincerely,

SMC MARTIN INC.

(b) (4) [redacted]

Soil Scientist

SEJ/elq
Enclosure

cc: Tom Walsh
Bob Zimmerman
Mike Apgar

RECEIVED
JUL 23 1985
WATER SUPPLY BRANCH

Greenwood Laboratories

ORIGINAL (RED)

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: June 14, 1985 GREENWOOD NO. GL 6650

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES:
GL 6650-1: MW-19-6/11 1:22 pm (Camdel Metals Corporation)
GL 6650-2: RW-1-6/11 1:43 pm
GL 6650-3: P-6/11 Pond 1:05 pm
GL 6650-4: LS-6/11 Lawn Spray 1:49 pm

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6650-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	6/11/85 MW-19	0	0	0	0
2	" RW-1	60 ug/L	0	0	1.7 ug/L
3	" Pond	7.1 ug/L	0	0	0
4	" LS (Lawn Spray)	6.1 ug/L	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del

Copy: R. Zimmerman, Handy & Harman; Millard Vaughn, Camdel Metals

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE · KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

ORIGINAL (RED)

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: June 19, 1985 GREENWOOD NO. GL 6655

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6655-1 thru -4: Camdel Metals (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6655-	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	6/14/85	RW1-6/14 1:12 pm	59 ug/L	0	0	1.9 ug/L
2	"	P-6/14 Pond 1:16 pm	0	0	0	0
3	"	LS-6/14 Lawn Spray	0	0	0	0
4	"	MW19-6/14 1:28 pm	0	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman Tube Co.; Millard Vaughn, Camdel Metals Corp.

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE · KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

ORIGINAL (RED)

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: June 19, 1985 GREENWOOD NO. GL 6658

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6658-1 thru -4: Camdel Metals (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6658-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	6/18/85 LS-6/18 Lawn Spray 11:55	0	0	0	0
2	" MW19-6/18 12:51	0	0	0	0
3	" RW1-6/18 11:50	54 ug/L	0	0	1.6 ug/L
4	" P-6/18 Pond 12:02	0	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman Tube Co.; Millard Vaughn, Camdel Metals Corp.

Greenwood Laboratories

ORIGINAL (RED)

ANALYTICAL CHEMISTS AND CONSULTANTS
903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348
PHONE: 215-388-7295

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: June 26, 1985 GREENWOOD NOS. GL 6663 & 6668

SUBJECT: Examination of water samples for content of trichloroethylene and related compounds.

SAMPLES: GL 6663-1 thru -4: Rec'd 6/21/85 pm (listed below) Camdel Metals
GL 6668-1 thru -4: " 6/25/85 pm (" ") " "

SUMMARY:

These two groups of samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6663-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW1-6/21 12:18 pm	64 ug/L	0	0	1.8 ug/L
2	PS-6/21 Pond Spray 1:06 pm	0	0	0	0
3	P-6/21 Pond 1:11 pm	0	0	0	0
4	MW19-6/21 1:22 pm	0	0	0	0
GL # 6668-					
1	RW1-6/25 1:11 pm	55 ug/L	0	0	0
2	MW19-6/25 1:37 pm	0	0	0	0
3	P-6/25 Pond 1:17 pm	0	0	0	0
4*	LS-6/25 Lawn Spray 1:34 pm	7.8 ug/L	0	0	0

(b) (4)
GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman Tube Co.; Millard Vaughn, Camdel Metals

ORIGINAL
(RED)

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: July 2, 1985 GREENWOOD NO. GL 6673

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6673-1 thru -4: Camdel Metals Corp.

SUMMARY:

These samples have been exmained by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6673-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1 6/28/85 12:20 pm	46 ug/L	0	0	1.8 ug/L
2	LS-6/28 " 12:28 pm	13 ug/L	0	0	0
3	MW-19 " 12:44 pm	0	0	0	0
4	Pond 6/28/85 12:50 pm	21 ug/L	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman Tube Co.; Millard Vaughn, Camdel Metals Corp.

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

ORIGINAL (RED)

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: July 9, 1985 GREENWOOD NO. GL 6675

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6675-1 thru -4: Camdel Metals (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows.

GL # 6675-	Sample Identity				C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	R-7/2	7/2/85	RW-1	1:14 pm	50 ug/L	0	0	2.3 ug/L
2	LS-7/2	"	Lawn Spray	1:17 pm	0	0	0	0
3	P-7/2	"	Pond	1:25 pm	4.6 ug/L	0	0	0
4	MW-7/2	"	MW-19	1:35 pm	0	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman Tube Co.; Millard Vaughn, Camdel Metals

Greenwood Laboratories

ORIGINAL (RED)

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

TO: (b) (4)
SMC MARTIN
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: July 10, 1985 GREENWOOD NO. GL 6683

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6683-1 thru -8: Camdel Metals (7/5/83 & 7/9/83)(listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6683-	Sample Identity				C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	R-7/5	7/5/85	12:13 pm	RW-1	48 ug/L	0	0	1.9 ug/L
2	LS-7/5	"	12:30 pm	Lawn Spray	0	0	0	0
3	P-7/5	"	12:16 pm	Pond	0	0	0	0
4	MW-7/5	"	1:11 pm	MW-19	0	0	0	0
5	R-7/9	7/9/85	12:51 pm	RW-1	36 ug/L	0	0	2.5 ug/L
6	LS-7/9	"	12:56 pm	Lawn Spray	9 ug/L	0	0	0
7	P-7/9	"	1:13 pm	Pond	0	0	0	0
8	MW-7/9	"	1:23 pm	MW-19	0	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman Tube Co.; Millard V. Vaughn, Camdel Metals

ORIGINAL (RED)

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

TO: (b) (4)
SMC MARTIN
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: July 16, 1985 GREENWOOD NO. GL 6685

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6685-1 thru -7: Camdel Metals (listed below).

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6685-	Sample Identity			C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1	7/12/85	12:13 pm	43 ug/L	0	0	2.3 ug/L
2	Ground Spray	"	12:15 pm	0	0	0	0
3	Pond	"	12:20 pm	0	0	0	0
4	MW-4	"	1:55 pm	13 ug/L	0	0	0
5	MW-17	"	1:20 pm	0	0	0	0
6	MW-19	"	1:35 pm	0	0	0	0
7	MW-7	"	2:15 pm	83 ug/L	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman Tube Co.; Camdel Metals, Millard V. Vaughn

SMC Martin

900 W. Valley Forge Road
P.O. Box 859
Valley Forge, Pennsylvania 19482
Telephone 215 265-2700 or 783-7480

ORIGINAL (RED)

November 15, 1985
Ref: 8713-040-94003

Mr. Michael Apgar
Department of Natural Resources
and Environmental Control
Water Resources Section
89 Kings Highway
P.O. Box 1401
Dover, DE 19903

Dear Mike:

Enclosed please find copies of the analyses for the ground water recovery program being conducted at Camdel metals. As of November 4, 1985, 14,424,600 gallons have been recovered and treated. Contaminant concentrations from the recovery well have remained below 40 ppb since August 30, 1985 and have continued to decline to a low of 17 ppb as of November 4, 1985. Weekly sampling will continue until contaminant concentrations in the recovery well have stabilized at or below 25 ppb.

A minor spill was reported by plant personnel during the week of August 19, 1985. Plant personnel discovered the leak and quickly replaced the faulty condenser. Contaminant concentrations in the recovery well reflect this spill and its subsequent recovery. I will continue to forward analytical results until the desired concentrations are achieved.

If you have any questions or concerns, please do not hesitate to contact me.

Sincerely,

SMC MARTIN INC.

(b) (4) [redacted]

Soil Scientist

SEJ:njs
8713/SEJL1N
Enclosure

cc: Tom Walsh - Camdel Metals Corp.
Bob Zimmerman - Handy & Harmon Tube Co., Inc.

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

ORIGINAL (RED)

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: July 22, 1985

GREENWOOD NO. GL 6690 & GL 6696

SUBJECT: Examination of water samples for trichlorethylene and related compounds.

SAMPLES: GL 6690-1 thru -4 Camdel Metals, 7/16/85, listed below
GL 6696-1 thru -4 " " , 7/19/85, " "

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedures. The analytical results for these two sets of samples are as follows:

GL # 6690-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1 7/16/85	44 ug/L	0	0	2.2 ug/L
2	Ground Spray 7/16/85	0	0	0	0
3	Pond 7/16/85	0	0	0	0
4	MW-19 "	0	0	0	0
GL # 6696-					
1	RW-1 7/19/85	43 ug/L	0	0	2.2 ug/L
2	Pond "	5.3 ug/L	0	0	0
3	Ground Spray 7/19/85	0	0	0	0
4	MW-19 7/19/85	0	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman; Millard Vaughn, Camdel Metals

SMC Martin

900 W. Valley Forge Road
P.O. Box 859
Valley Forge, Pennsylvania 19482
Telephone 215 265-2700 or 783 7480

ORIGINAL (RED)

PFE

ORIGINAL (Red)

February 19, 1986
Ref: 8713-040-94003

Mr. Michael Apgar
Department of Natural Resources
& Environmental Control
Water Resources Section
89 King Highway
P. O. Box 1401
Dover, DE 19903

Dear Mike:

Enclosed please find copies of the analyses for the ground-water recovery program being conducted at Camdel Metals. These analyses include weekly results from December 2, 1985 through the combined quarterly and weekly sampling of February 3, 1986 and compliment the previous results submitted on November 15, 1985. As of February 13, 1986, 19,402,600 gallons have been recovered and treated. Although contaminant concentrations in the recovery well have remained below the target concentration of 25 ppb since January 24, 1986, contaminant concentrations in Monitor Wells 4 and 7 are in excess of the agreed upon target concentration (50 ppb). Contaminant concentrations in these wells are not reflected in contaminant concentrations in the recovered water due to dilution and volatilization factors. Weekly sampling of the recovery well, ground spray, pond, Monitor Well 19 and quarterly sampling of Monitor Wells 4, 7, and 17 will continue. I will continue to forward analytical results until the desired concentrations are achieved.

If you have any questions or concerns, please do not hesitate to contact me.

Sincerely,
SMC MARTIN INC.

(b) (4) [redacted]

Soil Scientist

SEJ:rm
Enclosures
8713:SEJL1J

cc: Tom Walsh
Bob Zimmerman

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7294

TO: (b) (4)
SMC MARTIN
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: January 6, 1986 GREENWOOD NO. GL 6848

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6848-1 thru -4: Camdel Metals (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6848-	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	MW-19	1/3/86	0	0	0	0
2	Pond	"	~ 2 ug/L	0	0	0
3	Ground Spray	"	~ 2 ug/L	0	0	0
4	RW-1	"	25 ug/L	0	0	1.7 ug/L

(b) (4)
GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman Tube Co. Millard V. Vaughn, Camdel Metals Corp.

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

ORIGINAL (RED)

PFE

ORIGINAL (Red)

TO: (b) (4)
SMC MARTIN
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: October 14, 1985 GREENWOOD NO. GL 6770

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6770-1 thru -4: Camdel Metals Corporation

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6770-	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	10/11/85	RW-1	34 ug/L	0	0	2.2 ug/L
2	"	Pond	1.8 ug/L	0	0	0
3	"	Lawn Spray	4.9 ug/L	0	0	0.2 ug/L
4	"	MW-19	0	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: Millard Vaughn, Camdel Metals Corp; R. Zimmerman, Handy & Harman Tube Co.

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: August 26, 1985 GREENWOOD NO. GL 6726

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6726-1 thru -4: Camdel Metals (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6726-	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1	8/23/85	170 ug/L	0	0	1.8 ug/L
2	Ground Spray	"	2.9 ug/L	0	0	0
3	Pond	"	4.5 ug/L	0	0	0
4	MW-19	"	0	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman Tube Co.; Millard V. Vaughn, Camdel Metals Corp.

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: December 23, 1985 GREENWOOD NO. GL 6839

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6839-1 thru -4: Camdel Metals Corporation (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6839-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	12/20/85 RW-1	26 ug/L	0	0	1.9 ug/L
2	" Ground Spray	6.9 ug/L	0	0	0.7 ug/L
3	" Pond	3.5 ug/L	0	0	0.2 ug/L
4	" MW-19	0	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman lube co.; Millard Vaughn, Camdel Metals Corp.

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

TO: (b) (4)
SMC MARTIN
P.O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: November 27, 1985 GREENWOOD NO. GL6817

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL-6817-1 thru -4 Camdel Metals Corp. (listed below).

SUMMARY:

These samples were examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6817-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1 Corner Building 11/20/85	27 µg/L	0	0	2.1 µg/L
2	Pond Pond "	2.5 µg/L	6.8 µg/L	0	0
3	MW-19 Field Well "	0	0	0	0
4	Ground Spray Sprinkler "	2.0 µg/L	0	0	0.2µg/L

(b) (4)

GREENWOOD LABORATORIES

GRU/mjl
Copy: R. Zimmerman; Millard Vaughn, Camdel Metals Corp.

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ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7292

PFE

ORIGINAL (Red)

ORIGINAL (RED)

ORIGINAL (RED)

TO: (b) (4)

SMC MARTIN
P. O. box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: December 2, 1985 GREENWOOD NO. GL 6822

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6822-1 thru -4: Camdel Metals Corporation (listed below).

SUMMARY:

These samples have been examined by gas chromatograpby using the previously described procedure. The analytical results are as follows:

GL # 6822-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1 11/26/85	29 ug/L	0	0	2.1 ug/L
2	Pond "	18 ug/L	16 ug/L	0	0
3	Ground Spray 11/26/85	2.7 ug/L	0	0	0.3 ug/L
4	MW-19 11/26/85	0	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman Tube Co.; Millard Vaughn, Camdel Metals Corp.

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903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

PFE ORIGINAL (Red)

ORIGINAL (RED)

TO: (b) (4)
SMC MARTIN
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: December 5, 1985 GREENWOOD NO. GL 6825

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6825-1 thru -4: Camdel Metals Corporation (listed below).

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6825-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1 12/3/85	28 ug/L	0	0	2.1 ug/L
2	Pond "	0	0	0	0
3	Field Spray "	14 ug/L	0	0	0.5 ug/L
4	MW-19	0	0	0	0

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GRU:del
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ORIGINAL (RED)

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: January 16, 1986 GREENWOOD NO. GL 6853

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6853-1 thru -4: Camdel Metals Corporation (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6853-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	1/13/86 RW-1	26 ug/L	0	0	0.2 ug/L
2	" Ground Spray	9.5 ug/L	4.8 ug/L	0	0.6 ug/L
3	" Pond	6.6 ug/L	0	0	0.6 ug/L
4	" MW-19	0	0	0	0

(b) (4)

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ORIGINAL (RED)

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: February 19, 1986 GREENWOOD NO. GL6886

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES:
GL 6886-1: RW-1 2/13/86
GL 6886-2: Pond "
GL 6886-3: Ground Spray 2/13/86
GL 6886-4: MW-19 2/13/86

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6886-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	2/13/86 RW-1	23 ug/L	0	0	2.2 ug/L
2	" Pond	8.3 ug/L	0	0	0
3	" Ground Spray	7.2 ug/L	0	0	0.5 ug/L
4	" MW-19	0	0	0	0

(b) (4)
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GRU:del
Copy: R. Zimmerman, Handy & Harman; Millard Vaughn, Camdel Metals

REFERENCE 3

REFERENCE 3A

UNIVERSITY OF DELAWARE
Water Resources Center

THE AVAILABILITY OF GROUND WATER IN KENT COUNTY, DELAWARE, WITH SPECIAL REFERENCE TO THE DOVER AREA

by

R. W. Sundstrom and T. E. Pickett

Newark, Delaware
June, 1968

Greenwood Laboratories

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TO: (b) (4)
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Valley Forge, PA 19482

FROM: (b) (4)

DATE: January 28, 1986 GREENWOOD NO. GL 6868

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6868-1 thru -4: Camdel Metals Corporation(listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6868-	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	1/24/86	RW-1	22 ug/L	0	0	2.0 ug/L
2	"	Ground Spray	6.2 ug/L	0	0	0.5 ug/L
3	"	Pond	4.1 ug/L	0	0	0.3 ug/L
4	"	MW-19	0	0	0	0

(b) (4)

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(RED)

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TO: (b) (4)
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FROM: (b) (4)

DATE: February 3, 1986 GREENWOOD NO. GL 6874

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6874-1 thru -7: Camdel Metals Corporation (listed below).

SUMMARY:

These samples have been examined by gas chromatography using the preivously described procedure. The analytical results are as follows:

GL # 6874-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	1/31/86 RW-1	22 ug/L	0	0	2.1 ug/L
2	" Ground Spray	6.8 ug/L	0	0	0.8 ug/L
3	" Pond	5.6 ug/L	0	0	0
4	" MW-19	0	0	0	0
5	" MW-17	6.0 ug/L	3.0 ug/L	0	0
6	" MW-7	120 ug/L	0	0	0.4 ug/L
7	" MW-4	86 ug/L	3.2 ug/L	0	0

(b) (4)
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PHONE: 215-388-7295

TO: (b) (4)
SMC Martin
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Valley Forge, PA 19482

FROM: (b) (4)

DATE: July 24, 1985 GREENWOOD NO. GL 6701

SUBJECT: Examiantion of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6701-1 thru -4: Camdel Metals (listed below)

SUMMARY:

These sampels have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6701-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	Pond 7/23/85	0	0	0	0
2	RW-1 "	37 ug/L	0	0	2.5 ug/L
3	MW-19 "	0	0	0	0
4	Ground Spray 7/23/85	4.0 ug/L	0	0	0

(b) (4)

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TO: (b) (4)
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FROM: (b) (4)

DATE: July 30, 1985 GREENWOOD NO. GL 6702

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6702-1 thru -4: Camdel Metals (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6702-	Sample Identity				C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	R-7/26	RW-1	7/26/85	10:24 am	32 ug/L	0	0	2.0 ug/L
2	FS-7/26	Field SSpray		10:34 am	0	0	0	0
3	P07/26	Pond	7/26/85	10:30 am	0	0	0	0
4	MW-7/26	MW-19	"	10:48 am	0	0	0	0

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ORIGINAL (RED) PFE ORIGINAL (Red)

TO: (b) (4)
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Valley Forge, PA 19482

FROM: (b) (4)

DATE: August 1, 1985 GREENWOOD NO. GL 6705

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6705-1 thru -4: Camdel Metals Corporation (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6705-	Sample Identity			C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	Ground (Field Spray	7/30/85	11:18 am	19 ug/L	0	0	0
2	RW-1	"	11:06 am	37 ug/L	0	0	2.1 ug/L
3	Pond	"	11:11 am	0	0	0	0
4	MW-19	"	11:30 am	0	0	0	0

(b) (4)

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TO: (b) (4)

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FROM: (b) (4)

DATE: October 30, 1985

GREENWOOD NO. GL 6794

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6794-1 thru -4: Camdel Metals Corporation (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6794-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	Ground Spray 10/28/85	2.4 ug/L	0	0	0.2 ug/L
2	RW-1 "	31 ug/L	0	0	1.6 ug/L
3	Pond "	1.8 ug/L	0	0	0
4	MW-19 "	0	0	0	0

(b) (4)

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TO: (b) (4)
SMC MARTIN
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Valley Forge, PA 19482

FROM: (b) (4)

DATE: August 6, 1985 GREENWOOD NO. GL 6706

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6706-1 thru -4: Camdel Metals Corp.

SUMMARY:

GL # 6706-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1 8713 8/2/85 11:45 am	35 ug/L	0	0	2.2 ug/L
2	Spray " " 11:50 am	0	0	0	0
3	Pond " " 11:47 am	0	0	0	0
4	MW-19 " " 11:58 am	0	0	0	0

(b) (4)
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TO: (b) (4)

SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: August 22, 1985

GREENWOOD NO. GL 6723

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6723-1 thru -4: Camdel Metals Corp.

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6723-	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1	8/16/85	44 ug/L	0	0	2.3 ug/L
2	Ground Spray	"	4.6 ug/L	0	0	0
3	Pond	"	0	0	0	0
4	MW-19	"	0	0	0	0

(b) (4)

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ANALYTICAL CHEMISTS AND CONSULTANTS

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PHONE: 215-388-7295

ORIGINAL (RED)

ORIGINAL (Red)

TO: (b) (4)
SMC Martin
P. O. Box859
Valley Forge, PA 19482

FROM: (b) (4)

GREENWOOD NO. GL 6713

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6713-1 thru -4: Camdel Metals Corporation (listed below)

SUMMARY:

These samples have been examined by gas chromatogrpahy using the previously described procedure. The analytical results are as follows:

GL # 6713-	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1	8/9/8	46 ug/L	0	0	2.5 ug/L
2	Ground Spray	"	0	0	0	0
3	Pond	"	7.1 ug/L	0	0	0
4	MW-19	"	0	0	0	0

(b) (4)

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TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: August 8, 1985 GREENWOOD NO. GL 6710

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6710-1 thru -4: Camdel Metals Corporation (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6710	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1 8/6/85 12:15 pm	8/6/85	40 ug/L	0	0	1.9 ug/L
2	Ground Spray 12:18 pm	"	0	0	0	0
3	Pond 12:10 pm	"	0	0	0	0
4	MW-19 12:20 pm	"	0	0	0	0

(b) (4)

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PFE ORIGINAL (Red)

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: September 19, 1985 GREENWOOD NO. GL 6750

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6750-1 thru -4: Camdel Metals Corp.

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6750-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	9/19/85 Pond	0	0	0	0
2	" Ground Spray	4.5 ug/L	0	0	0.3 ug/L
3	" MW-19	0	0	0	0
4	" RW-1	39 ug/L	0	0	1.8 ug/L

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TO: (b) (4)
SMC MARTIN
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: October 8, 1985 GREENWOOD NO. GL 6765

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6765-1 thru -4: Camdel Metals Corporation (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6765-	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1	10/4/85	35 ug/L	0	0	1.8 ug/L
2	Pond	"	6.3 ug/L	0	0	0
3	Field Spray	"	3.4 ug/L	0	0	0.2 ug/L
4	MW-19	"	0	0	0	0

(b) (4)

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ORIGINAL (RED)

ORIGINAL (Red)

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: September 2, 1985 GREENWOOD NO. GL 6731

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6731-1 thru -6: Camdel Metals Corporation

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6731-		Sample IDentity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	8/30/85	RW-1	34 ug/L	0	0	1.8 ug/L
2	"	Ground Spray	2.7 ug/L	0	0	0
3	"	Pond	0	0	0	0
4	"	MW-19	0	0	0	0
5	"	MW-5	7.2 ug/L	0	0	0
6	"	MW-6	4.8 ug/L	0	0	0

(b) (4)

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PHONE: 215-388-7295

TO: (b) (4)
SMC MARTIN
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Valley Forge, PA 19482

FROM: (b) (4)

DATE: November 6, 1985 GREENWOOD NO. GL 6802

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6802-1 thru -4: Camdel Metals Corp. (listed below).

SUMMARY:

These samples were examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6802-	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1	11/4/85	17 µg/L	0	0	1.7 µg/L
2	Pond	"	5.8 µg/L	0	0	0
3	Spray	"	~1 µg/L	0	0	0.2 µg/L
4	MW-19	"	0	0	0	0

(b) (4)
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TO: (b) (4)
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P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: October 24, 1985 GREENWOOD NO. GL 6786

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6786-1 thru -4: Camdel Metals Corporation.

SUMMARY:

These samples have been examined by gas chromatography using the preivously described procedure. The analytical results are as follows:

GL # 6786-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	Ground Spray 10/21/85	3.1 ug/L	0	0	0
2	RW-1 10/21/85	37 ug/L	0	0	1.9 ug/L
3	MW-19 "	0	0	0	0
4	Pond "	0	0	0	0

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TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: September 10, 1985 GREENWOOD NO. GL 6740

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6740-1 thru -3: Camdel Metals Corporation

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6740-	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	9/6/85	RW-1	30 ug/L	0	0	0.3 ug/L
2	"	Pond	0	0	0	0
3	"	Ground Spray	3.8 ug/L	0	0	0

(b) (4)

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Valley Forge, PA 19482

FROM: (b) (4)

DATE: September 17, 1985 GREENWOOD NO. GL 6743

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6743-1 thru -4: Camdel Metals Corporation

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6743-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	9/13/85 RW-1	39 ug/L	0	0	2.0 ug/L
2	" MW-19	0	0	0	o
3	" Pond	0	0	0	o
4	" Spray Field	4.1 ug/L	0	0	o

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: Robert Zimmerman, Handy & Harman Tube Co.; MIllard V. Vaughn, Camdel Metals Cor

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ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

TO: (b) (4)
SMC MARTIN
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: January 6, 1986 GREENWOOD NO. GL 6848

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6848-1 thru -4: Camdel Metals (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6848-	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	MW-19	1/3/86	0	0	0	0
2	Pond	"	~ 2 ug/L	0	0	0
3	Ground Spray	"	~ 2 ug/L	0	0	0
4	RW-1	"	25 ug/L	0	0	1.7 ug/L

(b) (4)

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GRU:del
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ORIGINAL (RED)

PFE

ORIGINAL (Red)

TO: (b) (4)

SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: December 23, 1985 GREENWOOD NO. GL 6839

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6839-1 thru -4: Camdel Metals Corporation (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6839-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	12/20/85 RW-1	26 ug/L	0	0	1.9 ug/L
2	" Ground Spray	6.9 ug/L	0	0	0.7 ug/L
3	" Pond	3.5 ug/L	0	0	0.2 ug/L
4	" MW-19	0	0	0	0

(b) (4)

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ORIGINAL (RED)

PFE ORIGINAL (Red)

TO: (b) (4)
SMC MARTIN
P.O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: November 27, 1985 GREENWOOD NO. GL6817

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL-6817-1 thru -4 Camdel Metals Corp. (listed below).

SUMMARY:

These samples were examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6817-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1 Corner Building 11/20/85	27 µg/L	0	0	2.1 µg/L
1					
2	Pond Pond "	2.5 µg/L	6.8 µg/L	0	0
3	MW-19 Field Well "	0	0	0	0
4	Ground Spray Sprinkler "	2.0 µg/L	0	0	0.2µg/L

(b) (4)

GREENWOOD LABORATORIES

GRU/mjl
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PHONE: 215-388-7295

ORIGINAL (RED)

PFE

ORIGINAL (Red)

TO: (b) (4)
SMC MARTIN
P. O. box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: December 2, 1985 GREENWOOD NO. GL 6822

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6822-1 thru -4: Camdel Metals Corporation (listed below).

SUMMARY:

These samples have been examined by gas chromatograpby using the previously described procedure. The analytical results are as follows:

GL # 6822-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1 11/26/85	29 ug/L	0	0	2.1 ug/L
2	Pond "	18 ug/L	16 ug/L	0	0
3	Ground Spray 11/26/85	2.7 ug/L	0	0	0.3 ug/L
4	MW-19 11/26/85	0	0	0	0

(b) (4)

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ORIGINAL (RED)

PFE ORIGINAL (Red)

TO: (b) (4)
SMC MARTIN
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: December 5, 1985 GREENWOOD NO. GL 6825

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6825-1 thru -4: Camdel Metals Corporation (listed below).

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6825-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1 12/3/85	28 ug/L	0	0	2.1 ug/L
2	Pond "	0	0	0	0
3	Field Spray "	14 ug/L	0	0	0.5 ug/L
4	MW-19	0	0	0	0

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SMC Martin
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PFE
ORIGINAL
(Red)

FROM: (b) (4)

DATE: January 16, 1986 GREENWOOD NO. GL 6853

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6853-1 thru -4: Camdel Metals Corporation (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6853-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	1/13/86 RW-1	26 ug/L	0	0	0.2 ug/L
2	" Ground Spray	9.5 ug/L	4.8 ug/L	0	0.6 ug/L
3	" Pond	6.6 ug/L	0	0	0.6 ug/L
4	" MW-19	0	0	0	0

(b) (4)

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TO: (b) (4)
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FROM: (b) (4)

DATE: February 19, 1986 GREENWOOD NO. GL6886

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES:
GL 6886-1: RW-1 2/13/86
GL 6886-2: Pond "
GL 6886-3: Ground Spray 2/13/86
GL 6886-4: MW-19 2/13/86

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6886-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	2/13/86 RW-1	23 ug/L	0	0	2.2 ug/L
2	" Pond	8.3 ug/L	0	0	0
3	" Ground Spray	7.2 ug/L	0	0	0.5 ug/L
4	" MW-19	0	0	0	0

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TO: (b) (4)
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FROM: (b) (4)

DATE: January 28, 1986 GREENWOOD NO. GL 6868

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6868-1 thru -4: Camdel Metals Corporation(listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6868-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	1/24/86 RW-1	22 ug/L	0	0	2.0 ug/L
2	" Ground Spray	6.2 ug/L	0	0	0.5 ug/L
3	" Pond	4.1 ug/L	0	0	0.3 ug/L
4	" MW-19	0	0	0	0

(b) (4)

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ORIGINAL (Red)

TO: (b) (4)
SMC Martin
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Valley Forge, PA 19482

FROM: (b) (4)

DATE: February 3, 1986 GREENWOOD NO. GL 6874

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6874-1 thru -7: Camdel Metals Corporation (listed below).

SUMMARY:

These samples have been examined by gas chromatography using the preivously described procedure. The analytical results are as follows:

GL # 6874-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	1/31/86 RW-1	22 ug/L	0	0	2.1 ug/L
2	" Ground Spray	6.8 ug/L	0	0	0.8 ug/L
3	" Pond	5.6 ug/L	0	0	0
4	" MW-19	0	0	0	0
5	" MW-17	6.0 ug/L	3.0 ug/L	0	0
6	" MW-7	120 ug/L	0	0	0.4 ug/L
7	" MW-4	86 ug/L	3.2 ug/L	0	0

(b) (4)
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ORIGINAL (RED)

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TO: (b) (4)
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P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: July 24, 1985 GREENWOOD NO. GL 6701

SUBJECT: Examiantion of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6701-1 thru -4: Camdel Metals (listed below)

SUMMARY:

These sampels have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6701-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	Pond 7/23/85	0	0	0	0
2	RW-1 "	37 ug/L	0	0	2.5 ug/L
3	MW-19 "	0	0	0	0
4	Ground Spray 7/23/85	4.0 ug/L	0	0	0

(b) (4)

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ORIGINAL (Red)

TO: (b) (4)
SMC Martin
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FROM: (b) (4)

DATE: July 30, 1985 GREENWOOD NO. GL 6702

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6702-1 thru -4: Camdel Metals (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6702-	Sample Identity				C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	R-7/26	RW-1	7/26/85	10:24 am	32 ug/L	0	0	2.0 ug/L
2	FS-7/26	Field SSpray		10:34 am	0	0	0	0
3	P07/26	Pond	7/26/85	10:30 am	0	0	0	0
4	MW-7/26	MW-19	"	10:48 am	0	0	0	0

(b) (4)
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ORIGINAL (RED)

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ORIGINAL (Red)

TO: (b) (4)

SMC MARTIN
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: August 1, 1985 GREENWOOD NO. GL 6705

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6705-1 thru -4: Camdel Metals Corporation (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6705-	Sample Identity			C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	Ground (Field Spray	7/30/85	11:18 am	19 ug/L	0	0	0
2	RW-1	"	11:06 am	37 ug/L	0	0	2.1 ug/L
3	Pond	"	11:11 am	0	0	0	0
4	MW-19	"	11:30 am	0	0	0	0

(b) (4)

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ORIGINAL (Red)

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: October 30, 1985 GREENWOOD NO. GL 6794

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6794-1 thru -4: Camdel Metals Corporation (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6794-	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	Ground Spray	10/28/85	2.4 ug/L	0	0	0.2 ug/L
2	RW-1	"	31 ug/L	0	0	1.6 ug/L
3	Pond	"	1.8 ug/L	0	0	0
4	MW-19	"	0	0	0	0

(b) (4)

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ORIGINAL (RED)

PFE

ORIGINAL (Red)

TO: (b) (4)
SMC MARTIN
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: August 6, 1985 GREENWOOD NO. GL 6706

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6706-1 thru -4: Camdel Metals Corp.

SUMMARY:

GL # 6706-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1 8713 8/2/85 11:45 am	35 ug/L	0	0	2.2 ug/L
2	Spray " " 11:50 am	0	0	0	0
3	Pond " " 11:47 am	0	0	0	0
4	MW-19 " " 11:58 am	0	0	0	0

(b) (4)

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ORIGINAL (RED)

PFE ORIGINAL (Red)

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: August 22, 1985 GREENWOOD NO. GL 6723

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6723-1 thru -4: Camdel Metals Corp.

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6723-	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1	8/16/85	44 ug/L	0	0	2.3 ug/L
2	Ground Spray	"	4.6 ug/L	0	0	0
3	Pond	"	0	0	0	0
4	MW-19	"	0	0	0	0

(b) (4)

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PFE ORIGINAL (Red)

TO: (b) (4)
SMC Martin
P. O. Box859
Valley Forge, PA 19482

FROM: (b) (4)

GREENWOOD NO. GL 6713

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6713-1 thru -4: Camdel Metals Corporation (listed below)

SUMMARY:

These samples have been examined by gas chromatogrpahy using the previously described procedure. The analytical results are as follows:

GL # 6713-	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1	8/9/8	46 ug/L	0	0	2.5 ug/L
2	Ground Spray	"	0	0	0	0
3	Pond	"	7.1 ug/L	0	0	0
4	MW-19	"	0	0	0	0

(b) (4)

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ORIGINAL (RED)

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ORIGINAL (Red)

TO: (b) (4)

SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: August 8, 1985 GREENWOOD NO. GL 6710

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6710-1 thru -4: Camdel Metals Corporation (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6710	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1 8/6/85 12:15 pm	8/6/85	40 ug/L	0	0	1.9 ug/L
2	Ground Spray 12:18 pm	"	0	0	0	0
3	Pond 12:10 pm	"	0	0	0	0
4	MW-19 12:20 pm	"	0	0	0	0

(b) (4)

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PFE ORIGINAL (Red)

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: September 19, 1985 GREENWOOD NO. GL 6750

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6750-1 thru -4: Camdel Metals Corp.

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6750-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	9/19/85 Pond	0	0	0	0
2	" Ground Spray	4.5 ug/L	0	0	0.3 ug/L
3	" MW-19	0	0	0	0
4	" RW-1	39 ug/L	0	0	1.8 ug/L

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TO: (b) (4)
SMC MARTIN
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: October 8, 1985 GREENWOOD NO. GL 6765

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6765-1 thru -4: Camdel Metals Corporation (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6765-	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1	10/4/85	35 ug/L	0	0	1.8 ug/L
2	Pond	"	6.3 ug/L	0	0	0
3	Field Spray	"	3.4 ug/L	0	0	0.2 ug/L
4	MW-19	"	0	0	0	0

(b) (4)

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ORIGINAL (RED)

TO: (b) (4)
SMC MARTIN
P. O. Box 859
Valley Forge, PA 19482

ORIGINAL (Red)

FROM: (b) (4)

DATE: October 14, 1985 GREENWOOD NO. GL 6770

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6770-1 thru -4: Camdel Metals Corporation

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6770-	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	10/11/85	RW-1	34 ug/L	0	0	2.2 ug/L
2	"	Pond	1.8 ug/L	0	0	0
3	"	Lawn Spray	4.9 ug/L	0	0	0.2 ug/L
4	"	MW-19	0	0	0	0

(b) (4)
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Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

ORIGINAL (RED)

PFE

ORIGINAL (Red)

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: August 26, 1985 GREENWOOD NO. GL 6726

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6726-1 thru -4: Camdel Metals (listed below)

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6726-	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1	8/23/85	170 ug/L	0	0	1.8 ug/L
2	Ground Spray	"	2.9 ug/L	0	0	0
3	Pond	"	4.5 ug/L	0	0	0
4	MW-19	"	0	0	0	0

(b) (4)

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ORIGINAL (RED)

PFE

ORIGINAL (Red)

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: September 2, 1985 GREENWOOD NO. GL 6731

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6731-1 thru -6: Camdel Metals Corporation

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6731-		Sample IDentity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	8/30/85	RW-1	34 ug/L	0	0	1.8 ug/L
2	"	Ground Spray	2.7 ug/L	0	0	0
3	"	Pond	0	0	0	0
4	"	MW-19	0	0	0	0
5	"	MW-5	7.2 ug/L	0	0	0
6	"	MW-6	4.8 ug/L	0	0	0

(b) (4)

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PHONE: 215-388-7295

ORIGINAL (RED)

PFE

ORIGINAL (Red)

TO: (b) (4)
SMC MARTIN
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: November 6, 1985 GREENWOOD NO. GL 6802

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6802-1 thru -4: Camdel Metals Corp. (listed below).

SUMMARY:

These samples were examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6802-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	RW-1 11/4/85	17 µg/L	0	0	1.7 µg/L
2	Pond "	5.8 µg/L	0	0	0
3	Spray "	~1 µg/L	0	0	0.2 µg/L
4	MW-19 "	0	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman; Millard Vaughn, Camdel Metals Corp.

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ORIGINAL (RED)

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

PFE
ORIGINAL (Red)

FROM: (b) (4)

DATE: October 24, 1985 GREENWOOD NO. GL 6786

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6786-1 thru -4: Camdel Metals Corporation.

SUMMARY:

These samples have been examined by gas chromatography using the preivously described procedure. The analytical results are as follows:

GL # 6786-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	Ground Spray 10/21/85	3.1 ug/L	0	0	0
2	RW-1 10/21/85	37 ug/L	0	0	1.9 ug/L
3	MW-19 "	0	0	0	0
4	Pond "	0	0	0	0

(b) (4)

GREENWOOD LABORATORIES

MJL:del
Copies: R. Zimmerman, Handy & Harman; Millard Vaughn, Camdel Metals Corp.

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PHONE: 215-388-7295

ORIGINAL (RED)

PFE

ORIGINAL (Red)

TO: (b) (4)

SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: September 10, 1985 GREENWOOD NO. GL 6740

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6740-1 thru -3: Camdel Metals Corporation

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6740-	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	9/6/85	RW-1	30 ug/L	0	0	0.3 ug/L
2	"	Pond	0	0	0	0
3	"	Ground Spray	3.8 ug/L	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: Robert Zimmerman, Handy & Harman; Millard Vaughn, Camdel Metals Corp.

Greenwood Laboratories

ANALYTICAL CHEMISTS AND CONSULTANTS

003 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

ORIGINAL (RED)

PFE

ORIGINAL (Red)

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: September 17, 1985 GREENWOOD NO. GL 6743

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6743-1 thru -4: Camdel Metals Corporation

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6743-	Sample Identity	C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	9/13/85 RW-1	39 ug/L	0	0	2.0 ug/L
2	" MW-19	0	0	0	o
3	" Pond	0	0	0	o
4	" Spray Field	4.1 ug/L	0	0	o

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: Robert Zimmerman, Handy & Harman Tube Co.; MIllard V. Vaughn, Camdel Metals Corp.

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ANALYTICAL CHEMISTS AND CONSULTANTS

903 E. BALTIMORE PIKE KENNETT SQUARE, PA. 19348

PHONE: 215-388-7295

ORIGINAL (RED)

PFE

ORIGINAL (Red)

TO: (b) (4)
SMC Martin
P. O. Box 859
Valley Forge, PA 19482

FROM: (b) (4)

DATE: December 12, 1985 GREENWOOD NO. GL 6829

SUBJECT: Examination of water samples for trichloroethylene and related compounds.

SAMPLES: GL 6829-1 thru -4: Camdel Metals Corporation (listed below).

SUMMARY:

These samples have been examined by gas chromatography using the previously described procedure. The analytical results are as follows:

GL # 6829-	Sample Identity		C_2HCl_3	CH_3CCl_3	$CHCl_3$	C_2Cl_4
1	12/9/85	RW-1	27 ug/L	0	0	2.0 ug/L
2	"	Ground Spray	7.4 ug/L	10 ug/L	0	0.6 ug/L
3	"	Pond	2.6 ug/L	0	0	0
4	"	MW-19	0	0	0	0

(b) (4)

GREENWOOD LABORATORIES

GRU:del
Copy: R. Zimmerman, Handy & Harman; Millard Vaughn, Camdel Metals

SMC Martin

900 W. Valley Forge Road
P.O. Box 859
Valley Forge, Pennsylvania 19482
Telephone 215 265-2700 or 783-7480

ORIGINAL (RED)

PFE

ORIGINAL (Red)

February 19, 1986
Ref: 8713-040-94003

Mr. Michael Apgar
Department of Natural Resources
& Environmental Control
Water Resources Section
89 King Highway
P. O. Box 1401
Dover, DE 19903

Dear Mike:

Enclosed please find copies of the analyses for the ground-water recovery program being conducted at Camdel Metals. These analyses include weekly results from December 2, 1985 through the combined quarterly and weekly sampling of February 3, 1986 and compliment the previous results submitted on November 15, 1985. As of February 13, 1986, 19,402,600 gallons have been recovered and treated. Although contaminant concentrations in the recovery well have remained below the target concentration of 25 ppb since January 24, 1986, contaminant concentrations in Monitor Wells 4 and 7 are in excess of the agreed upon target concentration (50 ppb). Contaminant concentrations in these wells are not reflected in contaminant concentrations in the recovered water due to dilution and volatilization factors. Weekly sampling of the recovery well, ground spray, pond, Monitor Well 19 and quarterly sampling of Monitor Wells 4, 7, and 17 will continue. I will continue to forward analytical results until the desired concentrations are achieved.

If you have any questions or concerns, please do not hesitate to contact me.

Sincerely,
SMC MARTIN INC.

(b) (4) [redacted]

Soil Scientist

SEJ:rm
Enclosures
8713:SEJL1J

cc: Tom Walsh
Bob Zimmerman

UNIVERSITY OF DELAWARE
Water Resources Center

THE AVAILABILITY OF GROUND WATER IN KENT COUNTY, DELAWARE, WITH SPECIAL REFERENCE TO THE DOVER AREA

by

R. W. Sundstrom and T. E. Pickett

Newark, Delaware
June, 1968

GEOLOGY

General Statement

In any hydrologic study an understanding of the geologic framework is essential. Conversely, hydrologic data is useful in mapping the distribution of geologic units. The structural orientation of sandy and clayey geologic units (aquifers and aquitards) partially controls the flow of ground water. By plotting the thickness and elevation of sandy geologic units from water well information, one can construct maps which suggest where and how deep to drill for water, and also give an idea of the quantity and quality of water to expect. The Delaware Geological Survey maintains a growing file of well data which provides points in mapping the three-dimensional geologic network.

The geology section of this report is a compilation of current knowledge of Kent County geology, based primarily on water well data, but also on previously published reports by the Delaware Geological Survey and others, as well as unpublished studies. Special test drilling using a truck-mounted auger was helpful in areas where further information was needed in the construction of maps. Discussions with Dr. Johan J. Groot, Dr. Robert R. Jordan, Mr. Nenad Spoljaric, and Mr. Kenneth D. Woodruff of the Delaware Geological Survey were very helpful in the compilation of this report. Their efforts are gratefully acknowledged. Thanks also go to Mr. Arnold Fogelgren, Field Engineer of the Geology Department, who was responsible for the drilling.

Particular attention has been paid to the geology of the Dover area because this is one of the most rapidly growing areas in Kent County, and water needs are likewise expanding.

General Geology of Kent County

Kent County lies entirely within the Atlantic Coastal Plain Province (figure 2). Sedimentary beds gently dip toward the Atlantic Ocean to the southeast at an approximate average dip of 15 feet per mile, forming a sedimentary wedge. Successively younger units dip less steeply, and most units tend to thicken in the downdip direction (figure 3). Maximum total thickness of sediments is about 2,200 feet in northwestern Kent County and

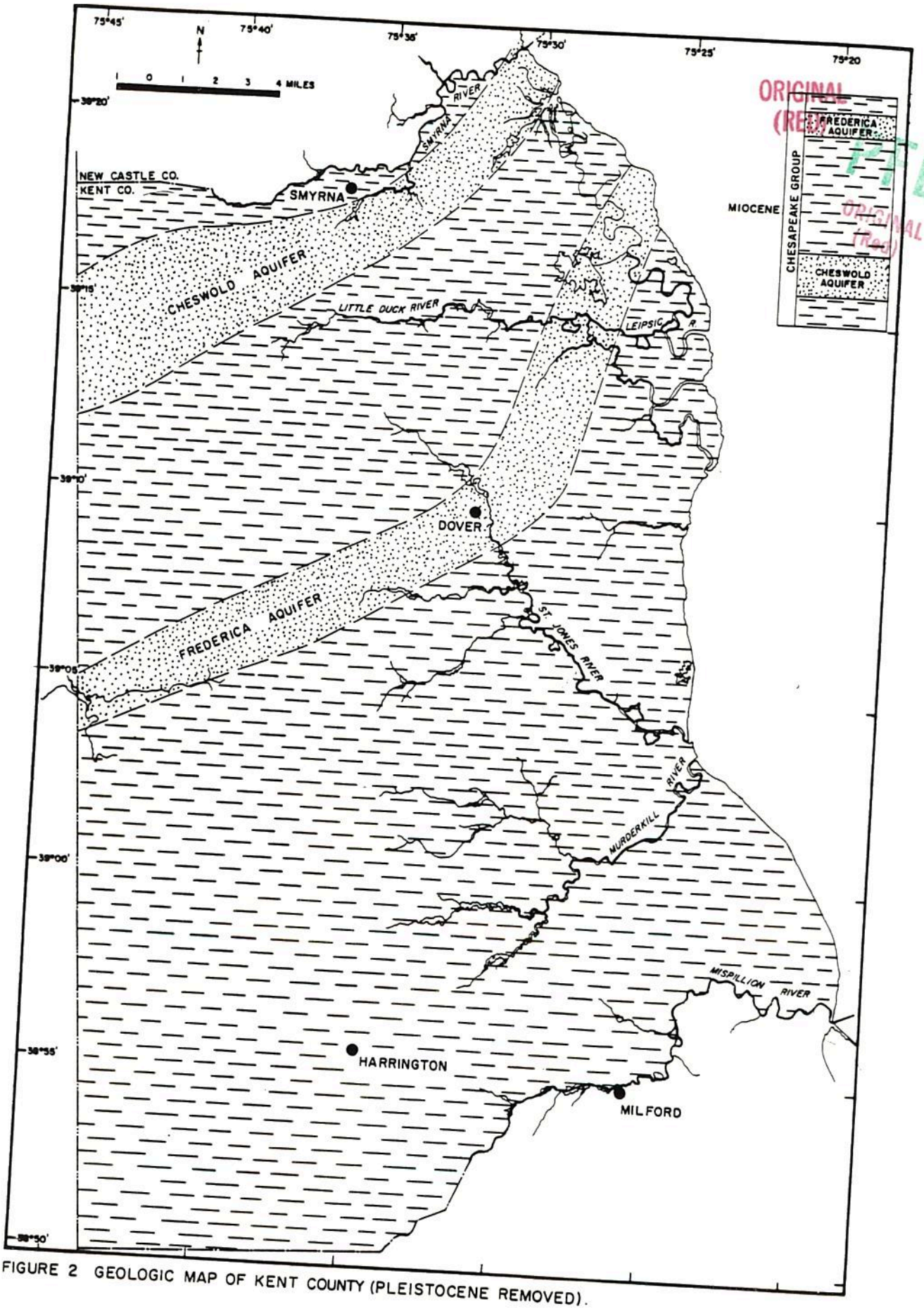

FIGURE 2 GEOLOGIC MAP OF KENT COUNTY (PLEISTOCENE REMOVED).

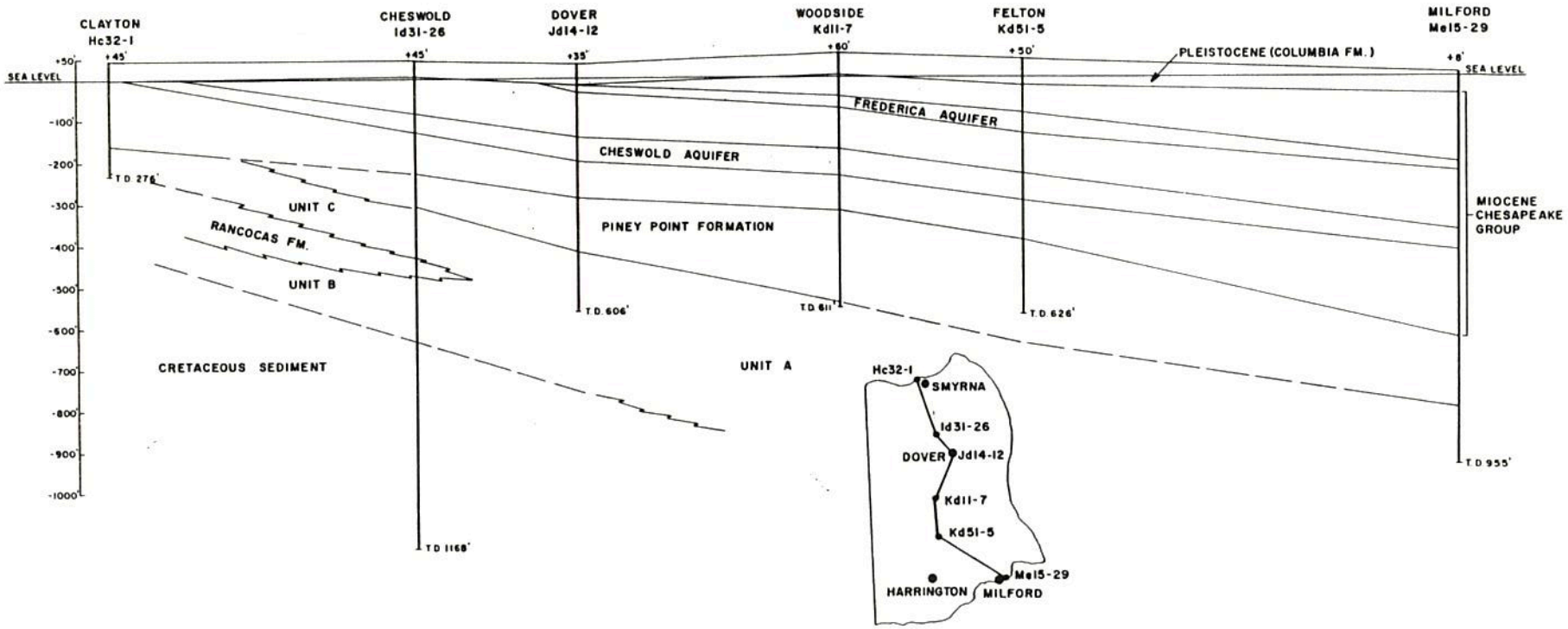

FIGURE 3. GEOLOGIC CROSS-SECTION OF KENT COUNTY.

4,200 feet in the southeastern part of the County. Sediments consist of unconsolidated gravels, sands, silts, and clays. The Coastal Plain is part of the Continental Shelf, and sediments are located in the landward extension of a coast-parallel trough called the Atlantic Coast Geosyncline.

Underlying the wedge of Coastal Plain sediments is the Basement Complex, which is the continuation, downdip, of the ancient metamorphic and igneous Piedmont rocks of northernmost Delaware. Nothing is known of these rocks first-hand in Kent County, because no wells to basement have been drilled in this County. However, they are presumed to be gneisses, schists, and gabbros because these are the rocks found in the Piedmont.

Sedimentary units in Kent County (table 1) record successive transgressions and regressions of the sea in this area. The oldest sediments in the Coastal Plain in Kent County are non-marine deposits (Potomac Formation) of Early to Late Cretaceous age. hey were deposited in fluvial environments. The Potomac and other units except the Columbia are not exposed at the surface in Kent County; therefore, all knowledge of them is derived from a very few deep wells and projections from their updip exposures in New Castle County. During Turonian time (Late Cretaceous), a marine transgression occurred. This initial transgression is marked by the Magothy Formation. Marine deposition continued with little or no break into Tertiary time, until at least the Middle Eocene. Deposited during this interval were the Cretaceous Matawan Formation (silty), the Monmouth Formation (sandy), the Eocene-Paleocene Units A, B, C (silty), the Rancocas Formation (sandy) and the Piney Point Formation (sandy). These units represent times of relative transgression (silty sediments) and regression (sandy sediments) of the sea. After Eocene time the area must have been above sea level, because no Oligocene sediments are known from the northern Atlantic Coastal Plain. However, the area was submerged again by a shallow sea during the latter part of the Miocene. During the Miocene the Chesapeake Group of silts, clays, and sands was deposited. Sands are found scattered throughout the Chesapeake Group, but the two main zones of sands in Kent County are called the Cheswold and Frederica aquifers. Sea level again dropped at the close of the Miocene, followed by a period of nondeposition and erosion during the Pliocene and perhaps part of the Pleistocene. Pleistocene (Columbia Formation) fluvial, and probable shoreline deposits in the southern part (Jordan, 1964), cover Kent County as a veneer. There are virtually no undisputed exposures of sediments older than Columbia in Kent County. Therefore, geologic work requires the study of well logs and samples.

TABLE 1

Distribution of Geologic Units in Kent County

Age	Name	Rock Type	Occurrence
Pleistocene	Columbia Fm.	Sand, gravel	Throughout Kent Co.
Miocene	Chesapeake Group	Silt, clay and sand	Throughout Kent Co.
	Frederica Aquifer	Medium to coarse sand	Central and Southern Kent Co.
	Cheswold Aquifer	Medium to coarse sand	Throughout all but N. Kent Co.
Eocene	Piney Point Fm.	Glauconitic sand and silt	Southern 4/5 Kent Co.
	Unit C	Glauconitic silt, sand and clay	Northern Kent Co.
Paleocene--Eocene	Rancocas Fm.	Glauconitic sand and silt	Northern Kent Co.
Cretaceous Paleocene--Eocene	Unit A	Glauconitic silt and clay	Southern 4/5 Kent Co.
Cretaceous Paleocene	Unit B	Glauconitic silt, clay, sand	Northern Kent Co.
Late Cretaceous	Monmouth Fm.	Glauconitic sand and silt	Throughout Kent Co.
	Matawan Fm.	Fine sand, silt, clay	Throughout Kent Co.
	Magothy Fm.	Sand and silt interbedded	Throughout Kent Co.
Early Cretaceous	Potomac Fm.	Variegated clay and sand, interbedded	Throughout Kent Co.

Major Geohydrologic Units

The term "geohydrologic unit" is used to refer to a mappable sandy zone, which forms a ground water reservoir, that can be demonstrated to be a unit by hydrologic as well as geologic data. Thus, when Pleistocene or Columbia Formation, Frederica aquifer, Cheswold aquifer, Piney Point Formation, or Rancocas Formation are referred to in this report, the reference is to be a permeable sandy unit of which the total thickness given is the total sand thickness. Table 2 shows the stratigraphic distribution of the geohydrologic units as well as other geologic units which are fine-grained and essentially aquitards. Important aquifers are indicated. The table also shows their stratigraphic equivalents in Maryland and New Jersey.

Structural and thickness maps of these textural units have been prepared using electric and gamma ray log data as well as geologists' and drillers' descriptive logs on file at the Delaware Geological Survey. Some core and ditch samples were also studied. Other samples used in preparing the maps were collected during the Kent County drilling program conducted by the Delaware Geological Survey during the winter and spring of 1967-68. Elevations shown on the maps in this report are in feet relative to sea level.

The oldest sediments in Kent County, of Cretaceous age, are mentioned only briefly in this report because not much is known of them and they are probably too fine grained and salty to be good sources of water in Kent County; whereas in New Castle County the Cretaceous is an aquifer. The Cretaceous is divided into the Lower non-marine Cretaceous (Potomac) and the Upper marine Cretaceous (Magothy, Matawan, Monmouth).

The Potomac Formation, used extensively for water in New Castle County, has been reached in only two wells in Kent County at depths of approximately 1,123 feet at Cheswold and 1,400 feet at the Dover Air Force Base. The Potomac Formation contains white and gray sand and some gravel; variegated white, yellow, and red silts and clays which are lignitic in places (Rasmussen, Groot, Depman 1958). The individual sand layers in the Potomac in New Castle County are generally not continuous horizontally for any extent and occur in sandy "zones" rather than distinct geologic units, and this is probably true in Kent County.

The Magothy Formation is a white and buff quartz sand with beds of gray or black clayey silt (Jordan, 1962, p. 9). It has been penetrated by only two wells in Kent County: the International Latex Company well at Cheswold and the Dover Air Force Base well. Depths to the top of the Magothy Formation are about 1,050 feet at Cheswold and about 1,335 feet at the Dover Air Force Base.

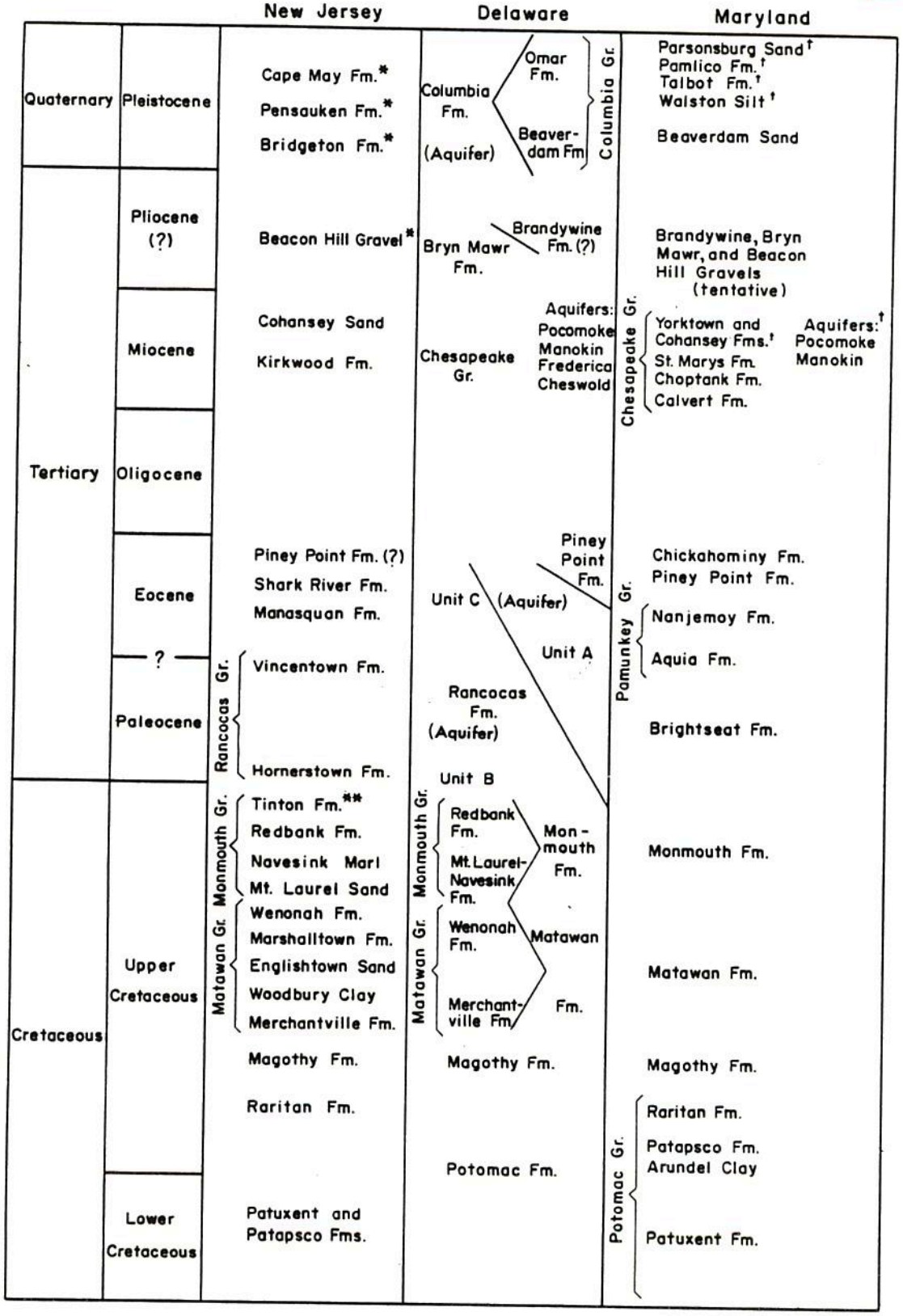

Table 2. Correlation chart of the Coastal Plain units in New Jersey, Delaware, and Maryland. The section for New Jersey is adapted from Kasabach and Scudder (1961) and Kümmel (1940). The Maryland section is adapted from Rasmussen and Slaughter (1955).

*Not always separable into formations and may be collectively termed "yellow gravel series".

**Monmouth County only.

† Divisions recognized only in part of the Eastern Shore.

FROM JORDAN, 1962

The Matawan and Monmouth Formations in the Dover well (Rasmussen, Groot and Depman 1958) are, respectively, clay to clayey sand and clayey sand. Therefore, they are apparently poor aquifers in Kent County.

Paleocene - Eocene

Rancocas Formation

The Rancocas Formation is a green and grayish or slightly brownish-green, fine to medium-grained, silty, glauconitic sand (Jordan, 1962, p. 18). It has been dated as Late Paleocene or Early Eocene age (Jordan, 1962, p. 19).

The Rancocas Formation crops out in southern New Castle County in the Middletown-Odessa area and dips southeast, in the subsurface, into northern Kent County as a sandy tongue of green- id surrounded by the finer-grained glauconitic unnamed Units A, B and C (figure 3). The Rancocas dips underneath the younger Piney Point Formation and probably loses its identity as a unit just south of Cheswold. The International Latex well at Cheswold contains the southern-most evidence of the Rancocas Formation. South of this point it apparently grades into the fine-grained sediments of Unit A.

Because of its limited extent in Kent County, the Rancocas Formation forms one of the least productive geohydrologic units in the County. It is found at depths ranging from about 50 feet below sea level in the northwest corner of Kent County to about 200 feet near Smyrna (figure 4), to a depth of 400 feet below sea level in the International Latex well at Cheswold. The sand tongue at Cheswold is separated from the overlying Piney Point Formation by about 110 feet of Unit C, which is a silty sand (.gure 3).

Piney Point Formation

The Piney Point Formation in Delaware is a green, medium and fine-grained, glauconitic sand (Jordan, 1962, p. 26). The glauconite content is important in distinguishing it from the overlying nonglauconitic Miocene sediment. The Piney Point has been dated as Jackson equivalent (Late Eocene) largely because of the lithology and presence of Jacksonian microfossils from the Dover Air Force Base well (Rasmussen, Groot, and Depman, 1958). Preliminary examination of the foraminifera in a 1968 well drilled by the City of Milford indicates that, at least for the downdip portion of the Piney Point Formation, a slightly older fauna (Early Eocene) may be present (Jordan, personal communication).

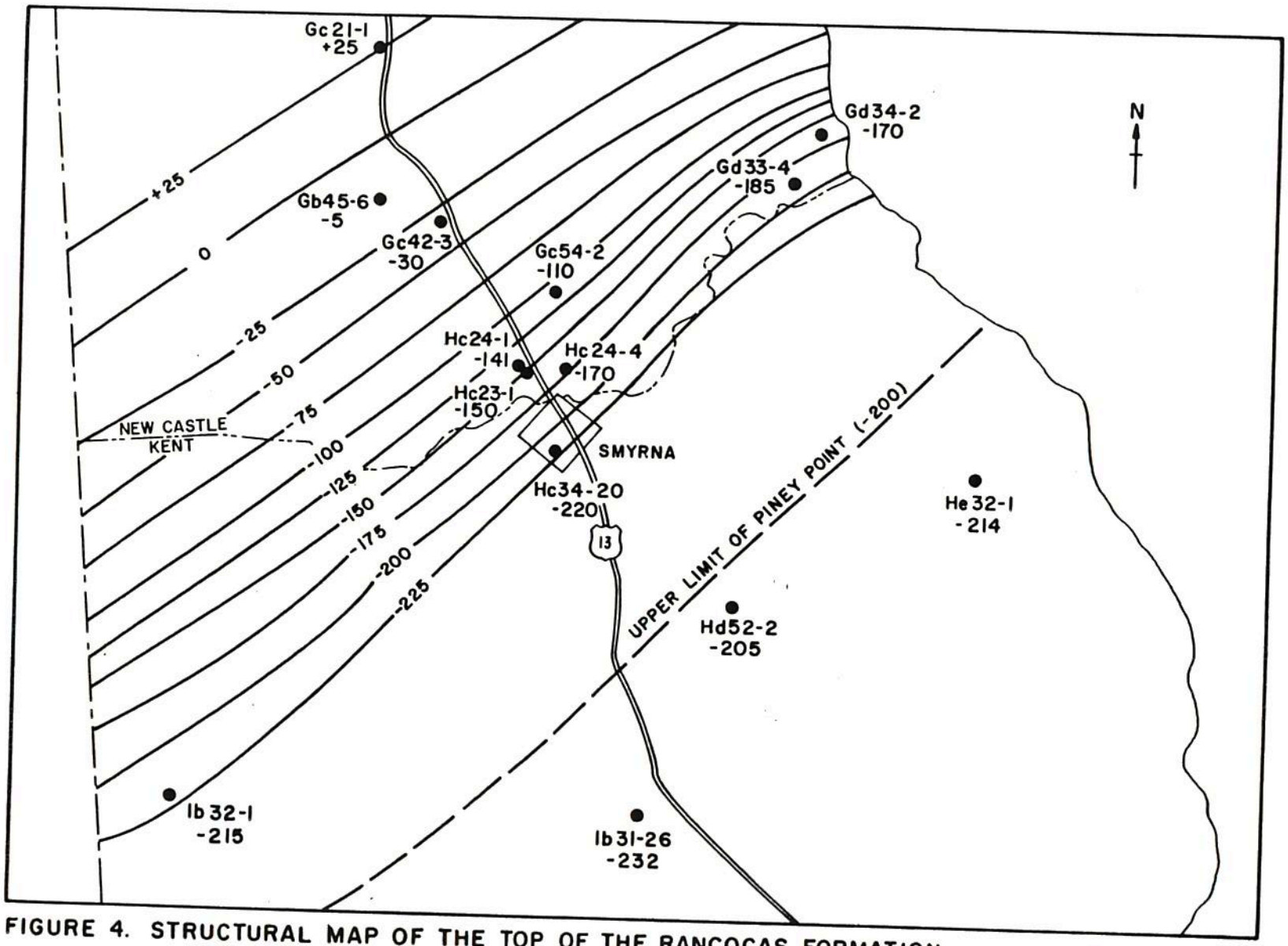

FIGURE 4. STRUCTURAL MAP OF THE TOP OF THE RANCOCAS FORMATION.

The Piney Point Formation lies entirely within the subsurface in Delaware. Nowhere is it found closer than 200 feet from the surface. It is an elongate lens of sand striking northeast-southwest and generally dipping toward the southeast. Because it is an easily mapped, distinct, sand unit, the Piney Point is given formational status. It is more easily mapped than the other geohydrologic units in Kent County.

The northern limit of the Piney Point Formation is north of Cheswold where it probably changes facies updip into the finer-grained Unit C. The upper surface of the Piney Point dips from a depth of 200 feet at the northern limit to about 630 feet at Milford (figure 5). The dip apparently increases southeasterly. Underlying the Piney Point south of the Cheswold area is Unit A, a finer-grained glauconitic sediment.

The Piney Point Formation is about 80 feet thick in the Cheswold area and 175 feet thick at Milford (figure 6). The thickest portion is in the area just south of Dover where it reaches about 250 feet at Woodside and the Dover Air Force Base. The thickest portion of this sedimentary lens is between Dover and Frederica and the lens thins both north and south.

The Piney Point Formation was recognized in Maryland before it was found in Delaware. Structural contours on maps by Otton (personal communication) of the Maryland Piney Point Formation are in accordance with those of Kent County prepared for this report. The extent of the Piney Point Formation in New Jersey is shown by Richards, Olmsted and Ruhle (1961). Their maps are also in essential agreement with those prepared for this report.

Limited water well data suggests that the Piney Point is located in a northeast-southwest trending trough, the axis of which is located between Dover and Frederica. This is the present location of the thickest sandy sediments. This may be a structural trough caused by warping of beds or it may be a facies change indicating the location of a beach environment. A beach environment would have thicker sand accumulation due to wave, wind, and current action just as on a modern beach. There is no way of assessing the thickness of Piney Point sediments removed by Oligocene and Miocene Pre-Chesapeake Group erosion, so the and may have been even thicker, originally.

The Piney Point Formation is much finer-grained at Milford than it is further north, and probably the Piney Point does not occur as a distinct sandy unit much farther south than Milford.

Miocene

The Miocene sediments in Delaware are collectively called the Chesapeake Group. They consist of predominantly gray and bluish-

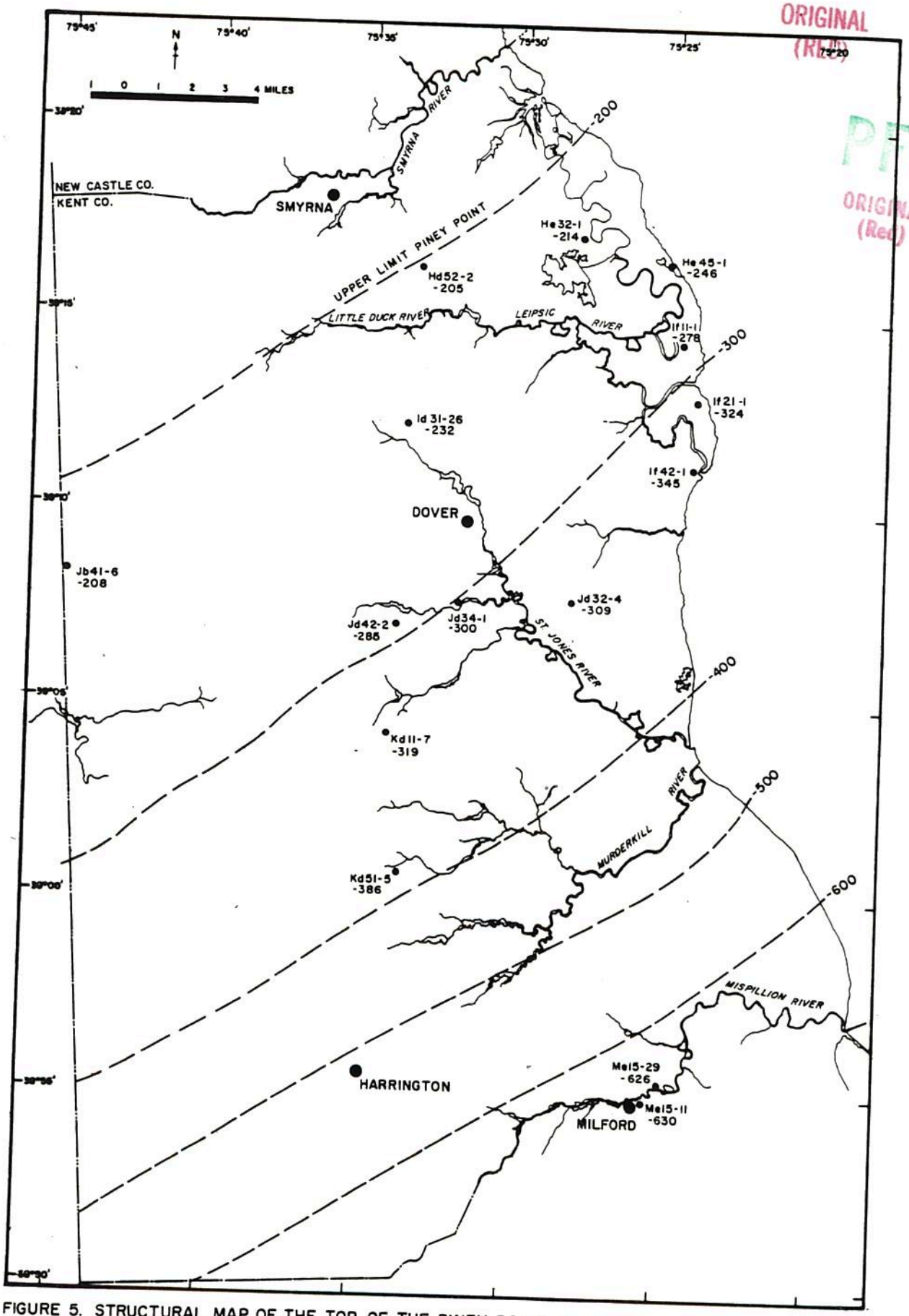

FIGURE 5. STRUCTURAL MAP OF THE TOP OF THE PINEY POINT FORMATION.

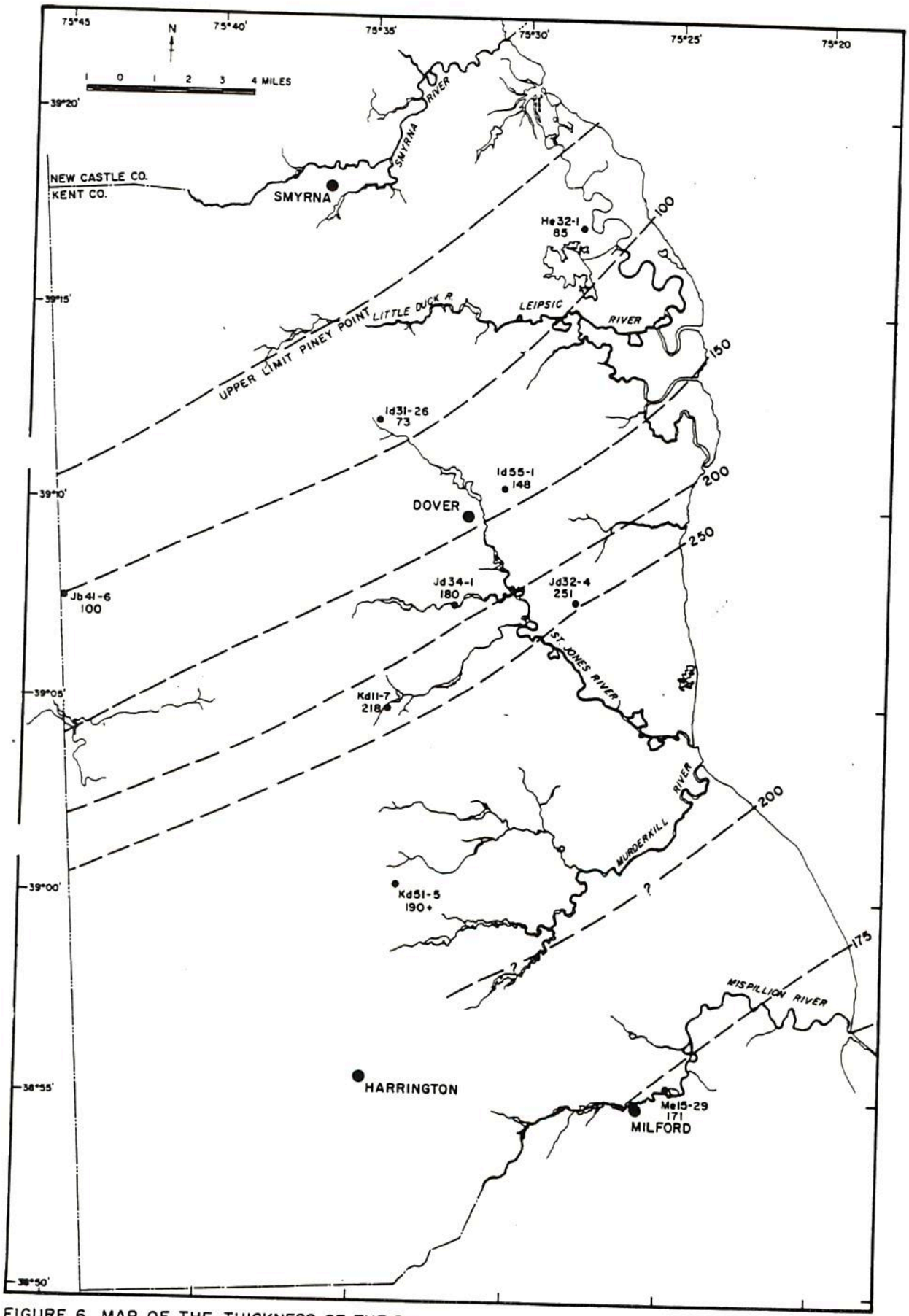

FIGURE 6. MAP OF THE THICKNESS OF THE PINEY POINT FORMATION.

gray silt containing beds of gray, fine-to medium-grained sand and some shell beds (Jordan, 1962, p. 27). The two main zones of sand in the Chesapeake Group are called Cheswold aquifer (lower unit) and Frederica aquifer (upper unit). A few unnamed thin sand bodies are present above the Frederica in southern Kent County.

The Delaware Chesapeake Group correlates with the Maryland Chesapeake Group (table 2). The Kirkwood and Cohansey units in New Jersey probably, in part, correlate with the Delaware Cheswold and Frederica (table 2). The name Calvert Formation from Maryland also has been applied to a large segment of the Delaware Miocene. However, the diatoms which are so prominent in the Calvert in Maryland are not as abundant in Kent County well cores (Jordan, 1962, p. 31).

The Miocene Chesapeake Group lies unconformably on the Paleocene-Eocene Units and Piney Point Formation (figure 3). It is overlain, separated by an angular unconformity, by Pleistocene sediments, which are frequently similar in color and texture to some of the Miocene sands. This is particularly true in the outcrop belt of the Frederica aquifer, in the Dover area.

The Chesapeake Group forms a wedge-shaped mass in Delaware starting just south of Middletown in New Castle County. It thickens and dips southeasterly to a maximum depth of about 1,550 feet under Fenwick Island (Rasmussen et al, 1960).

The sediments in the Chesapeake Group suggest a transgressive, regressive, transgressive, regressive sequence of sea level change. The sands of the Cheswold and Frederica were probably deposited under regressive, shallow water conditions. Probably none of the Chesapeake Group sediments were deposited under deep seas.

Cheswold Aquifer

The Cheswold aquifer is a sandy zone, not distinct enough as a geologic unit to be called a formation. It consists of medium to coarse sand and shells. The dominant color is gray (Marine, 1955, p. 113). The Cheswold is overlain and underlain by dominantly gray silts and clays of the Chesapeake Group (figure 3).

The depth of the top of the Cheswold aquifer ranges from around sea level in the updip area near Smyrna-Clayton to about 360 feet below sea level in the vicinity of Milford (figure 7). Probably the Cheswold continues as a unit for some distance into Sussex County.

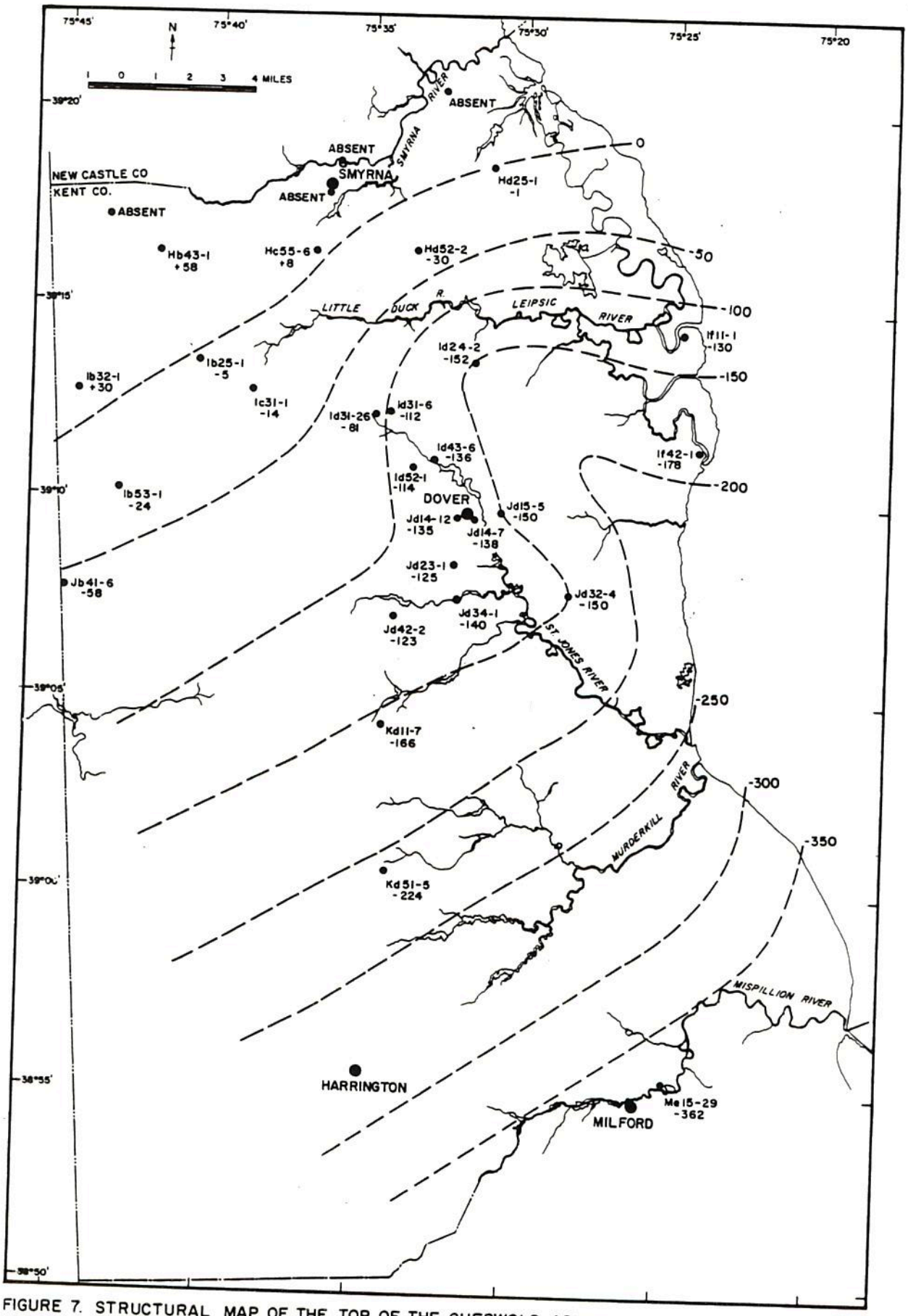

FIGURE 7. STRUCTURAL MAP OF THE TOP OF THE CHESWOLD AQUIFER.

The top of the Cheswold aquifer, between Smyrna and Dover, dips at about 11 feet per mile (Marine, 1955, p.113). This updip portion has been beveled by Pleistocene erosion and deposition (figure 3). This explains the wide distance between the 0 and 25 foot thickness contour lines in figure 8. The Cheswold thickens from this beveled area in the vicinity of Smyrna-Clayton to a maximum thickness of about 75-100 feet in an area centered north of the Town of Frederica and trending northeast-southwest (figure 8). The Cheswold thins again south of Frederica. Thus, the Cheswold is lens shaped. The thick area may have been a beach environment or a basin of thicker sand accumulation.

Frederica Aquifer

The Frederica aquifer is a sandy zone in the Chesapeake Group, above the Cheswold aquifer and separated from it by gray sandy silts. It consists of generally medium to coarse-grained sand with some material of gravel size and locally abundant shells (Marine, 1955, p. 117).

The Frederica is even less distinct a geologic unit than the Cheswold, and mapping it is more difficult than mapping any other geologic unit in Kent County with the exception of the Columbia. There are several Upper Miocene sands in Kent County, particularly in its southern part. It is often hard to judge from well information which of these units is the Frederica. Another difficulty is that in the outcrop belt of the Frederica, (figure 2), where it is found in contact with the overlying Columbia Formation, the similarity in lithology of the two units can be very confusing. Both Columbia and Frederica sediments can be medium to coarse light gray sand.

However, the Frederica aquifer is defined as the Upper Miocene sand found beneath the Town of Frederica at an elevation of about 125 feet below sea level, and this unit is the one mapped (figures 9, 10). Other Upper Miocene sands are generally thinner than those mapped as Frederica. Also, the Frederica is the only sand which can be traced all the way from Milford to Dover. It is possible that the non-Frederica Upper Miocene sands may be in part the updip portion of the Manokin aquifer, which is well-developed in Sussex County.

The Frederica dips southeasterly from the beveled updip edge which strikes northeast-southwest through Dover (figure 9). The elevation of the top of the Frederica reaches a maximum of -200 feet at Milford. The top of the Frederica aquifer between Camden and Milford dips at an average of 9 feet per mile (Marine, 1955, p. 113).

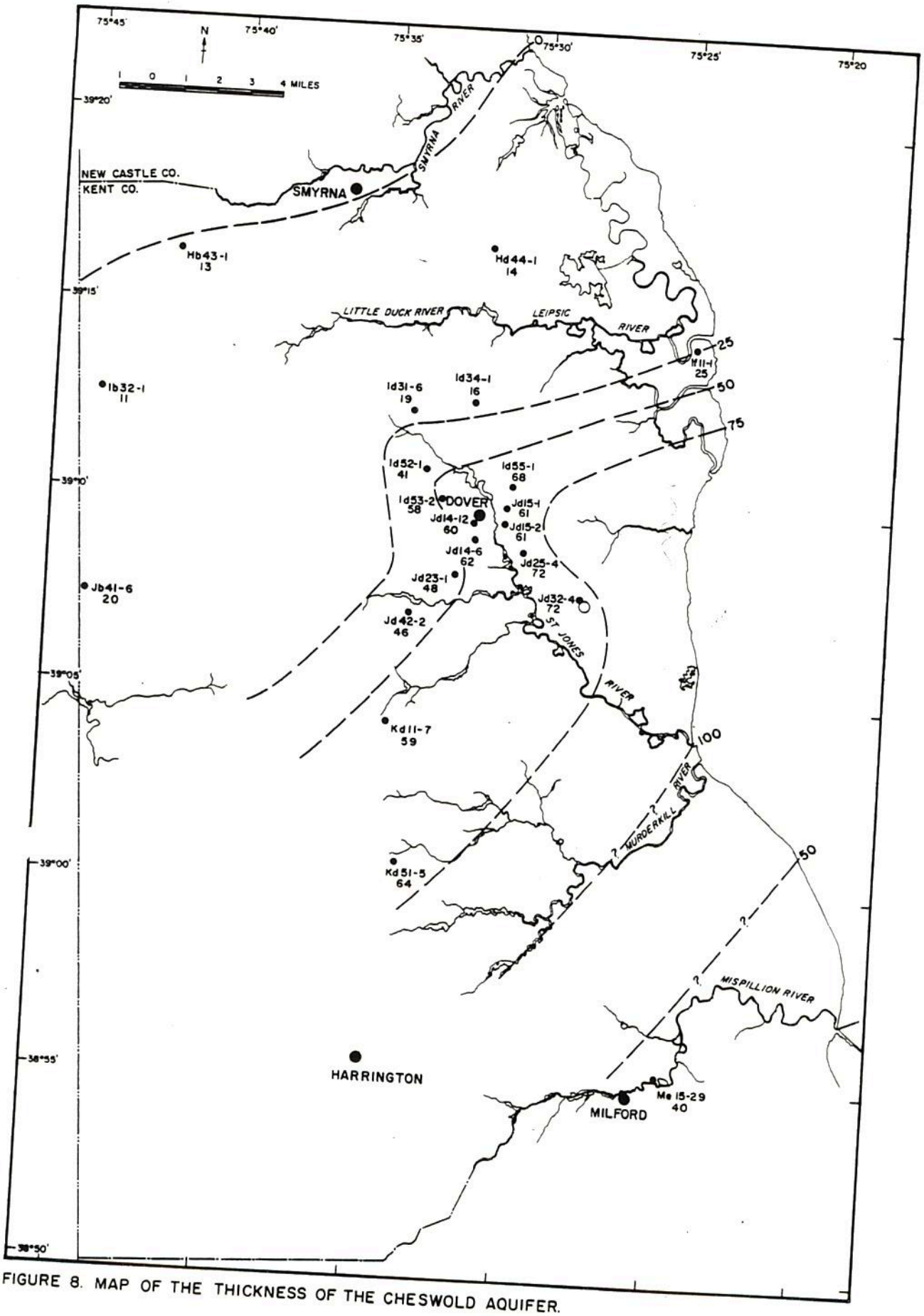

FIGURE 8. MAP OF THE THICKNESS OF THE CHESWOLD AQUIFER.

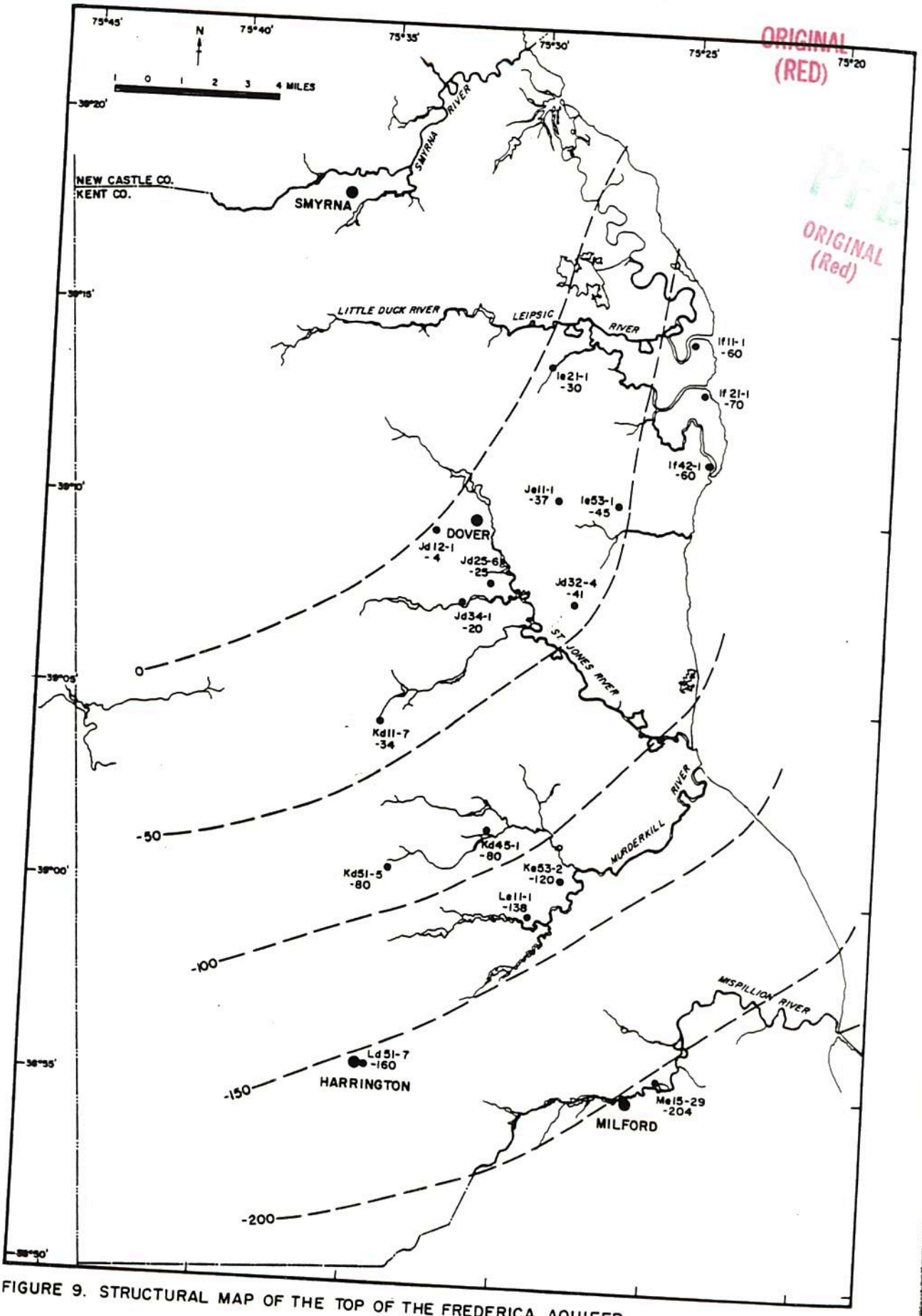

FIGURE 9. STRUCTURAL MAP OF THE TOP OF THE FREDERICA AQUIFER.

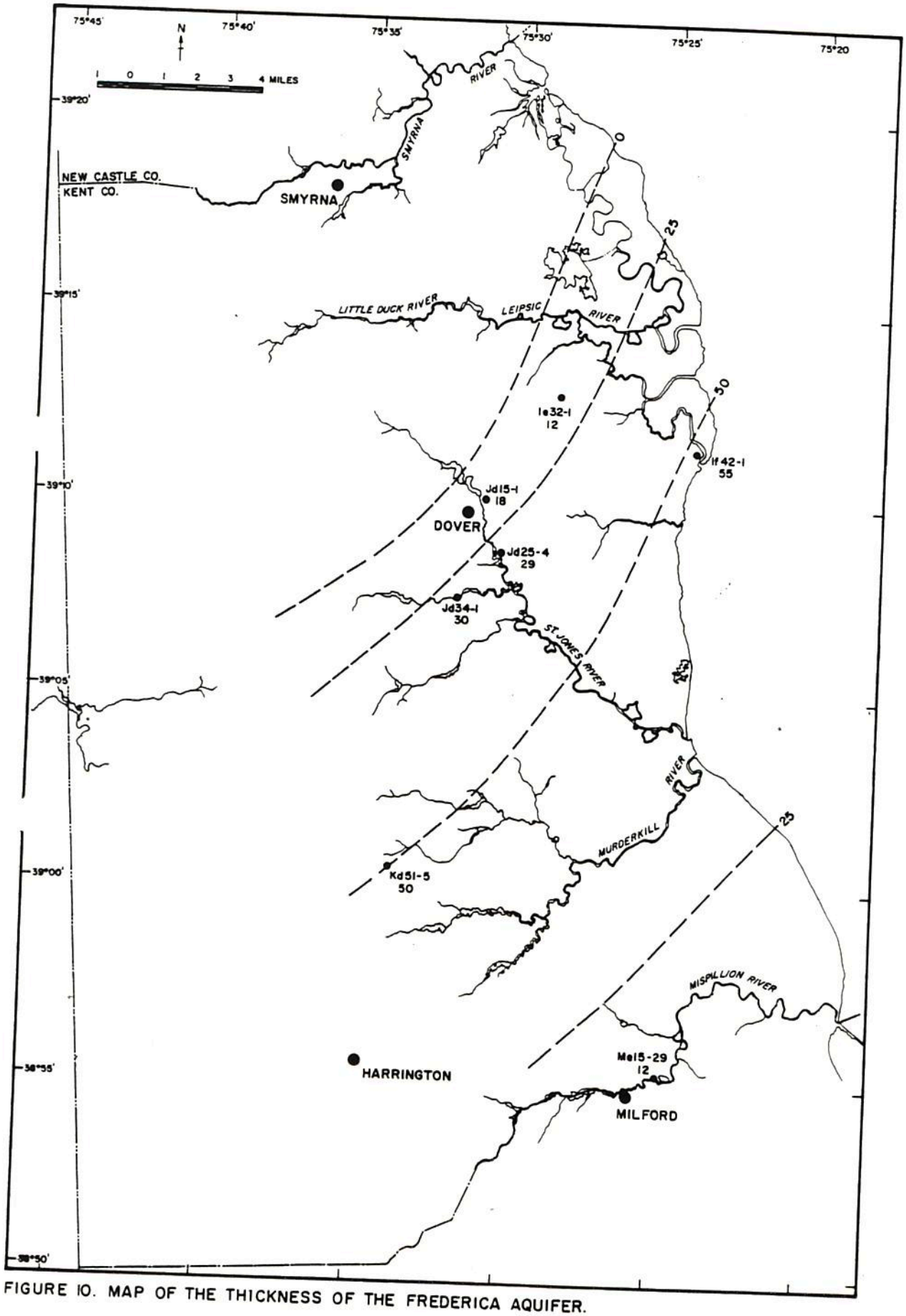

FIGURE 10. MAP OF THE THICKNESS OF THE FREDERICA AQUIFER.

East of Dover the contour lines on the top of the Frederica bend sharply to the north (figure 9). A possible explanation for this may be the removal of overlying Pleistocene sediments and part of the Frederica by erosion from the nearby Delaware River.

The Frederica thickens downdip from a pinch-out at Dover to a maximum of about 50 feet about 6 miles southeast of Dover (figure 10). It then thins downdip to about 12 feet at Milford and probably extends only a very short distance into Sussex County. In the Milford area the Frederica is virtually indistinguishable from other Upper Miocene sands because it is so thin.

It should be noted that the Frederica aquifer is thickest in the same general area that the Piney Point Formation and Cheswold aquifer are thickest. It has a similar elongate, lens-like shape. This suggests a possible structural basin or trough in the Coastal Plain, whose axis is located about 6 or 8 miles southeast of Dover and has a bearing of about N 45°E. This trough was receiving sediment at least from Eocene to Upper Miocene time because of the apparent coincidence of the greatest thickness of Eocene and Miocene sediment in this area.

Pleistocene

The Pleistocene series, also known as the Columbia Formation (Jordan, 1962, p. 44), is a mostly coarse, moderately sorted, quartz sand with a considerable admixture of gravel and commonly containing cobbles and, in some places, boulders. Thin silts may be present but are uncommon. It is generally cross-bedded. North of Dover Columbia sediments are generally yellow to dark reddish brown; but south of Dover they are frequently light gray or cream colored and easily confused with Miocene sands. However, toward the base of the lighter colored Columbia sands south of Dover yellow to dark orange-brown sands are encountered which are similar in color to the Columbia north of Dover. This may be evidence of Columbia marine encroachment over earlier fluvial Columbia sediments.

The Columbia sediments form a veneer over all the other Coastal Plain sediments in Delaware, and are separated from them by an angular unconformity. Because the Columbia sediments are more permeable nearly everywhere than the underlying sediments, they allow almost unrestricted recharge to the strata below.

A detailed thickness map of the Columbia sediments in Kent County is difficult to construct with the limited available data. Moreover, it is the nature of most of the Columbia sands to be uneven in thickness. The thickness is controlled by the type of depositional environment and by post-Pleistocene erosion. Therefore, the thickness map of the Columbia sediments (figure 11) has

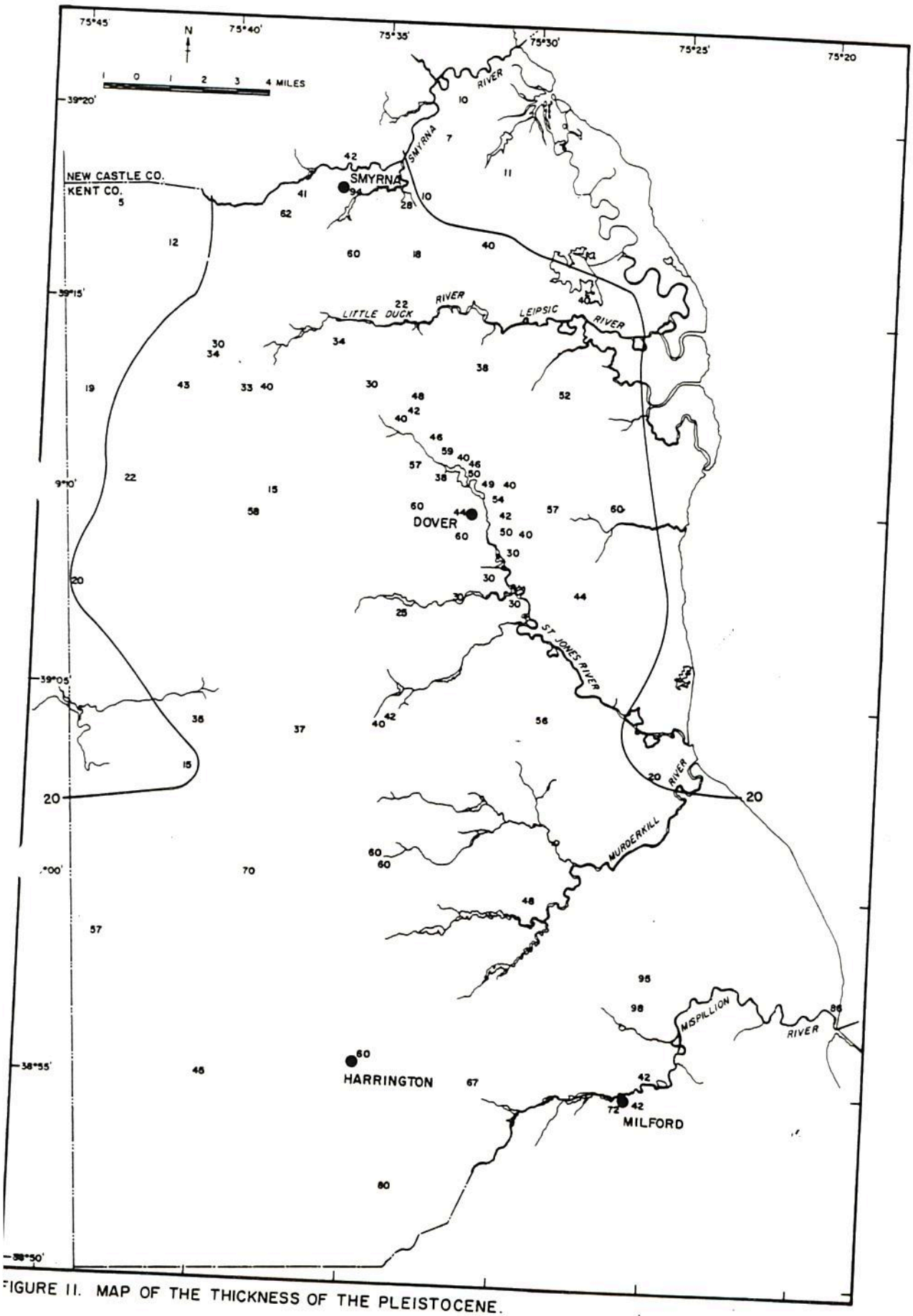

FIGURE 11. MAP OF THE THICKNESS OF THE PLEISTOCENE.

only the 20 foot contour line drawn and point thicknesses given for other areas. It is believed that the 20 foot contour line is the only one that could be drawn with any degree of accuracy.

Columbia sediment thicknesses in northern Kent County reflect braided stream channels typical of New Castle County. Spoljaric (1967) found that the Pleistocene channels in New Castle County become more braided southward. There appears to be a major channel in the Smyrna-Clayton area. This channel has a north-south trend.

The thickness of the Columbia thins to zero near the Delaware River (figure 11). The Delaware River, in Pleistocene time, cut its channel deeper and wider and in doing so, removed the Pleistocene cover. Modern river-derived organic-rich silts, clays, and fine sands now cover Miocene and older sediments in this area.

In the vicinity of Dover there is a transition from dominantly fluvial to marine conditions. Evidence for this is a change in color of the sediments (see above). Also, the sediment is finer and better sorted south of Dover than north of it. Some of the sands are laminated or mottled as in modern coastal environments. In addition, as shown on figure 11, there appears to be a change to a more uniform, thicker Pleistocene section in the southern one-fourth of Kent County. This area is possibly a relict Pleistocene shoreline. The more uniform thickness, finer grain size, and color are more typical of a marine than a fluvial sedimentary environment.

Jordan (1967, p. 12) designates Pleistocene sediments in southwestern Kent County as the informal "Staytonville unit." He earlier (1964) had referred to this area as "estuarine facies." The Staytonville unit consists predominantly of medium grained sands, although fine and coarse sands as well as silts are abundant. The unit is distinguished by its irregular and indistinct bedding and abrupt lateral and vertical color changes. In places it is mottled both in texture and in color. This mottling is similar to that done by burrowing organisms in an estuary.

Jordan (1964, p. 69) also mapped a small patch of "beach facies?" in southern Kent County, just north of Milford. This is further evidence of a Pleistocene shoreline in the area.

The texture and color of sediment samples from new test holes drilled for information in constructing figure 11 of this report suggest the existence of a Pleistocene shoreline in the general area of southern Kent County.

Dover Area Geology

The charge to the authors of this report was to investigate the water resources and geology of Kent County with particular emphasis on Dover. Dover is the most populated area in the County and has the largest need for water. Fortunately, there are many wells located in the Dover area from which geologic information can be gathered.

Dover is located just north of the "trough" of thickest sands of the Piney Point Formation, Cheswold and Frederica aquifers. It is also located just north of the transition zone of Pleistocene sediments from typically orange-tan fluvial sediments to better sorted, more uniformly thick, grayish, apparently marine sediments. Therefore, Dover is just north of being ideally situated, geohydrologically speaking.

The lower most useful aquifer, the Piney Point Formation, is between 100 and 180 feet thick in the Dover area (figure 12). It thickens rapidly downdip in south Dover.

The Piney Point Formation is found at a depth of approximately 285-300 feet below sea level in the Dover area (figure 13). On the basis of only six wells, there appears to be a shift in the strike of the Piney Point Formation from northeast-southwest on the northeast side of Dover to a more north-south strike on the southwest side of Dover. This may indicate a trough southeast of Dover (figure 13). However, the scanty data is not sufficient to make a positive statement.

The Cheswold and Frederica aquifers are both present in the Dover area but their indistinct upper and lower boundaries plus the scanty data precludes the construction of a meaningful map on the scale of the Dover maps (figures 12, 13).

The Cheswold is about 135 feet below sea level in the Dover area and is approximately 60 feet thick.

The Frederica aquifer has its updip end in the Dover area. Because the Frederica aquifer is overlain directly by the Columbia sediments here (figure 3), the two act as one geohydrologic unit.

The Columbia Formation thickness varies from about 40 to 60 feet in the Dover area. However, the effective thickness as a geohydrologic unit is more because Frederica sands directly underlie the Columbia. Although there is more Columbia thickness data in the Dover area than in any other area of Kent County, there is not enough information to construct a meaningful thickness map for the Dover area. Dover seems to be near the middle

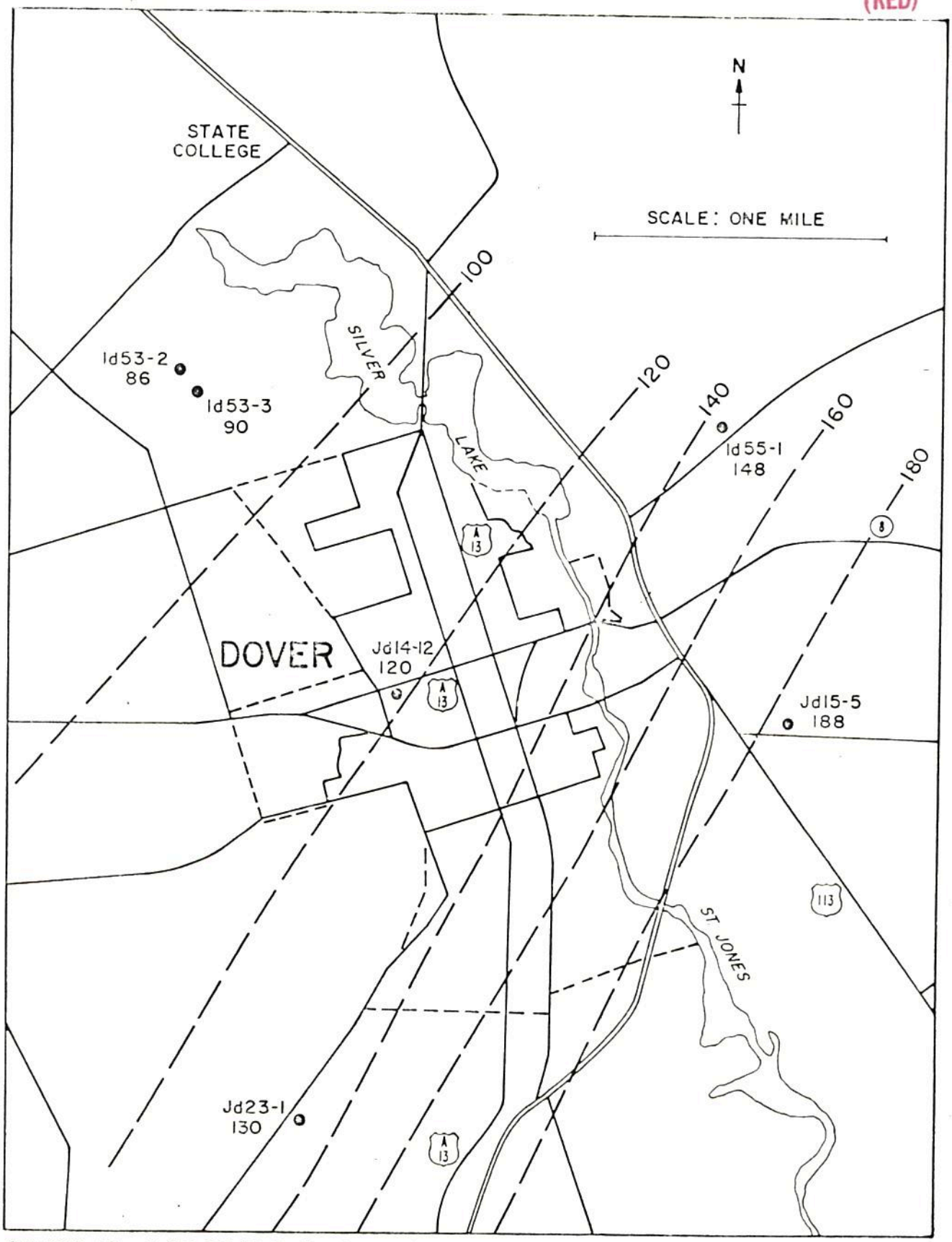

FIGURE 12. MAP OF THE THICKNESS OF THE PINEY POINT FORMATION IN THE DOVER AREA.

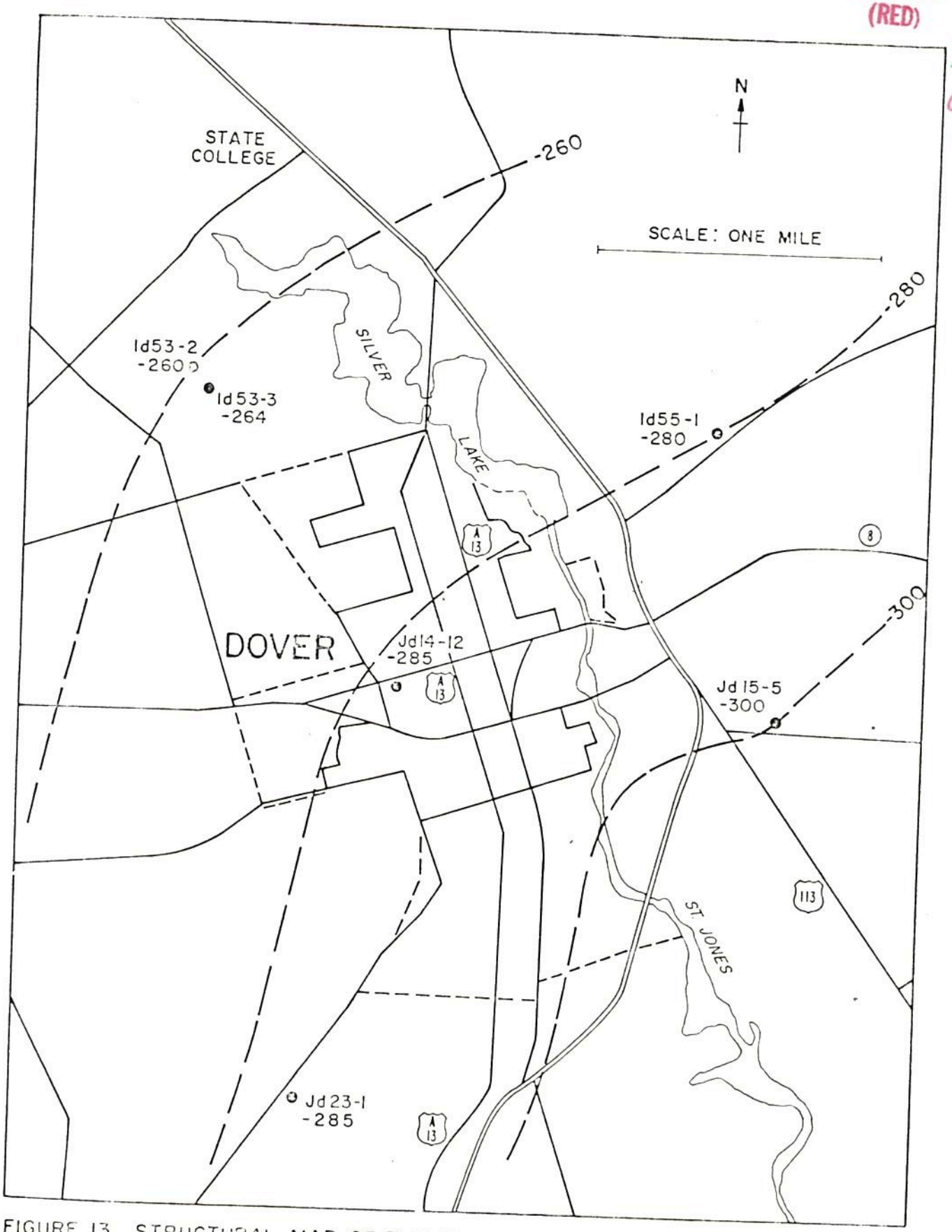

FIGURE 13. STRUCTURAL MAP OF THE TOP OF THE PINEY POINT FORMATION IN THE DOVER AREA.

of a central channel extending down the middle of Kent County. South of Dover the Columbia sediments change color from orange, reddish tan to light gray, become thicker, and also become more uniform in thickness. This probably represents a transitional facies between fluvial and marine Pleistocene environments.

Drilling Program for Kent County

Fifteen auger holes were drilled in connection with this study in order to gain more data in areas of scanty information (figure 14). The drilling was done by Mr. Arnold Fogelgren, Field Engineer, of the Geology Department using the University-owned power auger.

Auger cutting samples, samples peeled from the auger flights, and cores were taken and studied in order to construct the maps associated with this report.

The auger holes fulfilled several purposes: Those in northern Kent County helped determine the location of the updip emergence of the Cheswold aquifer under the Columbia sands (outcrop area). In the Dover area drilling helped determine the location of the updip emergence of the Frederica aquifer under the Columbia sands (outcrop area). The holes south of Dover helped determine the nature of Columbia sediments in this area and the depth to underlying Miocene sediments. All of the drilling in Kent County provided information on Columbia thickness.

The area of least geologic knowledge in Kent County is the southwestern part. Holes drilled here were particularly valuable. Part of this area is underlain by the Staytonville unit (Jordan, 1967, p. 12) which seems to be an area of transition from fluvial to marine deposition. Very little was known of the Staytonville unit at depth before drilling.

Additional holes in the area between Dover and the Towns of Frederica and Woodside might serve to delineate the "trough" where Piney Point, Cheswold, and Frederica sediments were found to be thickest (figure 3).

Drilling might also help solve the problem of differentiating Miocene and Pleistocene sands south of Dover and provide more information on the nature and configuration of Pleistocene shoreline environments in southern Kent County.

Summary

Evidence from well logs suggests that the Piney Point Formation extends farther north in Kent County than previously

The coefficient of storage at the East Dover Elementary School is twenty times higher than that at the Danner Farm well, although both are low. The coefficient of storage at the East Dover Elementary School is 0.0062 and at the Danner Farm test well 0.00031.

Hydraulic Boundaries of the Cheswold Aquifer

The outcrop of the Cheswold aquifer in the northern part of the County is sufficiently close to the pumping in the Dover-Dover Air Force Base area so that its favorable recharge image effect on the pumping levels in the wells is substantial and must be taken into account in computing the mutual interference between wells. Likewise, in any other part of the northern half of the County, recharge boundary effect will be favorable to the computed drawdowns.

The transmissive properties of the Cheswold vary greatly from place to place. Northwest, west and south of the Dover-Dover Air Force Base area the water-yielding properties of the Cheswold are not conducive to large yielding wells. No wells in this area are known to yield more than 300 gallons a minute, some are in the 100 to 200 gallons a minute range, many are in the 100 gallons a minute or less range, and in some localities the Cheswold does not yield a satisfactory supply. Although the Cheswold has poor water-yielding properties in places, it is believed that the continuity of the aquifer is such that no barrier boundaries of substantial magnitude exist.

Available Drawdown in the Cheswold Aquifer

The available drawdown at the time pumping began in the Cheswold aquifer ranged from no drawdown at 12 feet above sea level in the northwestern part of the County in the outcrop area to about 360 feet below sea level downdip at Milford. At Dover and at Milford the development of the Cheswold has been so intensive that the pumpage during peak demands in 1965, 1966 and 1967 has caused the drawdown to reach the top of the aquifer in four of the seven wells of the City of Dover and in one well in Milford. Table 21 lists the lowest pumping levels and the dates they occurred in the City of Dover wells along with the remaining available drawdown. The low drawdowns occurred during periods when the pumpage in the Dover area from the Cheswold aquifer averaged about 6,500,000 gallons daily. Additional draft on the Cheswold will necessitate adjustment in the rate of pumping of some of the Dover City wells.

REFERENCE 3B

STATE OF DELAWARE
UNIVERSITY OF DELAWARE

DELAWARE GEOLOGICAL SURVEY

Robert R. Jordan, State Geologist

BULLETIN No. 16

GROUND-WATER RESOURCES OF THE PINEY POINT AND CHESWOLD AQUIFERS IN CENTRAL DELAWARE AS DETERMINED BY A FLOW MODEL

BY

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PREPARED BY THE UNITED STATES GEOLOGICAL SURVEY
IN COOPERATION WITH THE
DELAWARE GEOLOGICAL SURVEY

NEWARK, DELAWARE

JULY 1982

(Jordan, 1962). Shells and shell fragments are common in the unit. Sundstrom and Pickett (1968) pointed out that these sediments represent a series of sea-level transgressions and regressions. Several aquifers have been identified in the Chesapeake Group on the peninsula, most notably the Cheswold, Federalsburg, Frederica, Manokin, and Pocomoke aquifers (Table 1). Of these, only the Cheswold aquifer is a significant aquifer in the study area; the rest of the Chesapeake Group sediments are considered to be confining beds in this study.

The lower sandy zone of the Chesapeake Group is the Cheswold aquifer. The aquifer is composed of fine to coarse sand and shells. Its thickness ranges from zero at its updip limit to more than 150 feet downdip. The aquifer is 50 to 75 feet thick in the Dover area. The top of the Cheswold aquifer ranges in depth from about sea level in the Smyrna-Clayton area to about 360 feet below sea level near Milford, in southern Kent County (Sundstrom and Pickett, 1968). Marine and Rasmussen (1955) reported the dip of the aquifer to be about 11 feet per mile between Smyrna and Dover. The Cheswold aquifer directly underlies the unconfined aquifer in a narrow subcrop belt about 8 miles north of Dover (Johnston and Leahy, 1977, Figure 4).

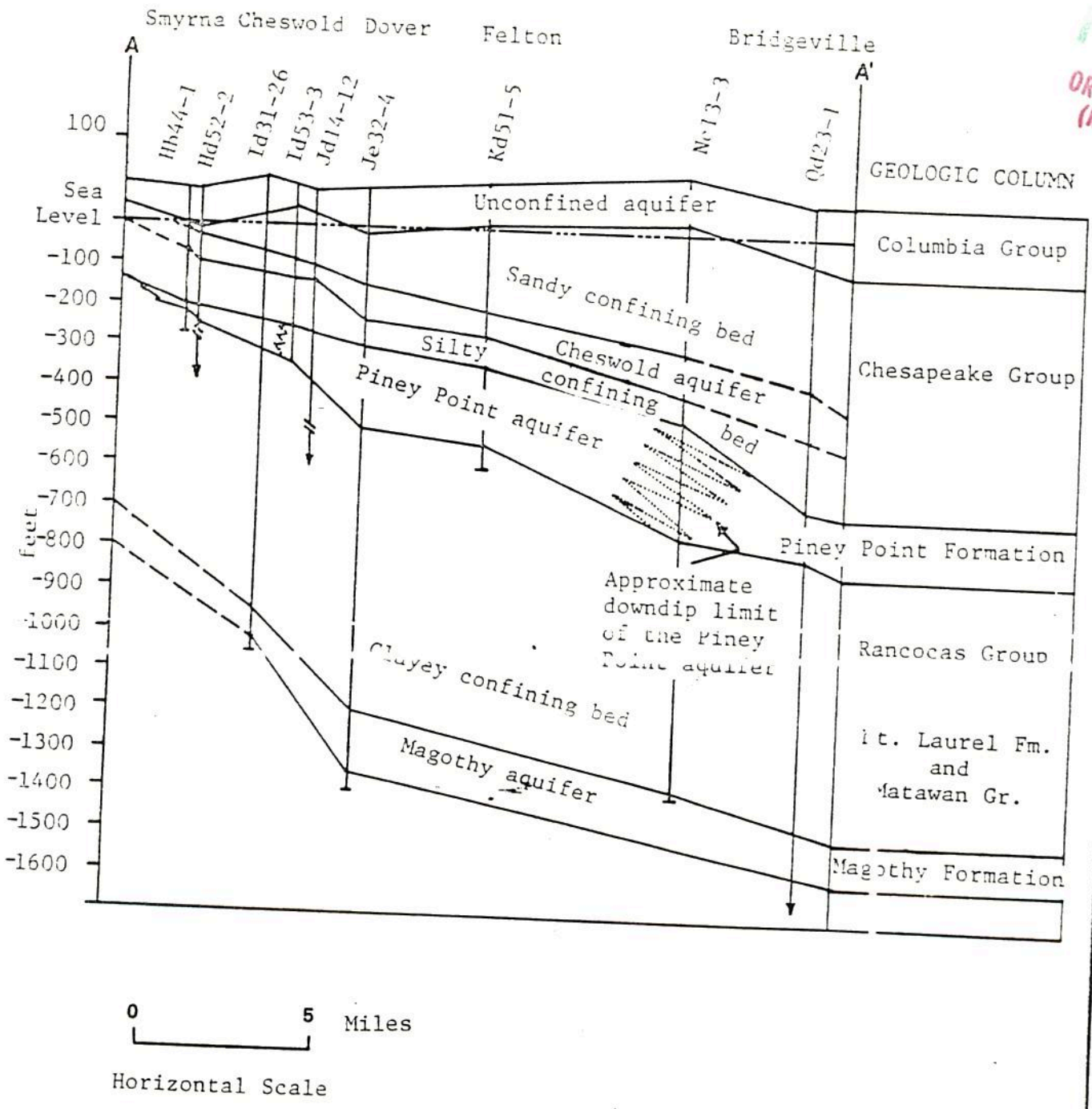
The Columbia Group (or Formation) overlies the Chesapeake Group and consists of fine to coarse sand occurring as a southward-thickening wedge across central and southern Delaware (Johnston, 1973). The Columbia Group is of Pleistocene age, mostly fluviatile in origin, and forms the water-table aquifer in most of Delaware (Jordan, 1962, 1964; Jordan and Talley, 1976). In some locations, the Columbia Group may rest directly upon the subcrop of an underlying Miocene aquifer with the entire sequence functioning as the water-table aquifer (Johnston, 1977). The saturated thickness of the unconfined aquifer ranges from about 15 feet north of Dover to about 170 feet near Milton. In the Dover area, the saturated thickness ranges from 15 to 56 feet.

Figure 5 shows a generalized geologic cross-section to the base of the Magothy aquifer. The section indicates the aquifers and confining beds modeled.

Movement of Ground Water

Before pumping began, hydraulic equilibrium prevailed in the aquifer system underlying Kent County. Recharge to the unconfined aquifer resulted from frequent periods of precipitation, and discharge occurred as evapotranspiration, base flow to streams, and downward leakage to the underlying Cheswold aquifer.

Prior to pumping, the Cheswold aquifer was recharged directly from the unconfined aquifer in its subcrop area and by downward leakage from the unconfined aquifer through the sandy confining bed in inland areas. Discharge was by upward leakage in coastal areas through the confining bed to the unconfined aquifer. The Cheswold aquifer probably received a very small amount of water by upward flow from deeper aquifers near the Delaware Bay, and discharged a very small amount of water by downward leakage to deeper aquifers inland.



Vertical Exaggeration 132x
Line of Section in Figure 1.

FIGURE 5 - GENERALIZED GEOLOGIC CROSS-SECTION FROM SMYRNA TO BRIDGEVILLE, DELAWARE.

The Piney Point aquifer neither crops out nor has a subcrop beneath an overlying aquifer, and all flow to and from the aquifer appears to be by vertical leakage through adjacent confining beds. Under prepumping conditions, the hydrology of the Piney Point aquifer involved recharge from overlying aquifers in updip areas, lateral movement through the aquifer, and discharge to overlying aquifers in downdip areas. The Piney Point aquifer probably also received extremely small amounts of water through upward leakage from the deeper Magothy aquifer.

The original hydrologic equilibrium within the Piney Point and Cheswold aquifers has been disturbed by the withdrawal of a large amount of water, causing two regional cones of depres ion to develop around Dover, Delaware. Pumping now accounts for a large part of the discharge from both aquifers within the study area. Water levels in the Piney Point and Cheswold aquifers have not stabilized in response to these pumping stresses, indicating that a new equilibrium has not been reached. Pumping has induced additional vertical leakage from the unconfined aquifer into underlying aquifers in the Dover area. This conclusion is supported by a reduction of approximately 30 percent or 10 cubic feet per second (ft^3/s) in the base flow of the St. Jones River near Dover (Johnston and Leahy, 1977).

If the present pumping scheme is maintained, the aquifers will eventually reach equilibrium. However, if future ground-water withdrawals increase in any aquifer of the system, additional time will be required for the aquifers to reach a new equilibrium.

Ground-Water Pumpage

The Piney Point and Cheswold aquifers provide approxima ely 80 percent of the total municipal and industrial water pumped in Kent County. Over 90 percent of the modeled pumpage from the Piney Point and Cheswold aqui ers occurs within the study area. Significant pumpage from the Piney Point aquifer in the vicinity of Cambridge, Maryland, (located approximately 50 miles southw st of Dover) has occurred in the period 1952-77. However, water levels in the m odeled area have not declined in response to these withdrawals (Williams, 1979, Pl te 4). Therefore, the Cambridge, Maryland, pumpage was not included in the model

The Magothy aquifer is essentially unpumped in Kent Count / because it is too deep and contains brackish water. Only one Magothy well locatec near Cheswold is being lightly pumped. Pumpage from the unconfined aquifer (Co umbia Formation) in the study area is light and widely distributed, and no long-te m decline in the water table has been observed (Johnston, 1977). Furthermore, th s pumpage is used primarily for irrigation and domestic supply and most of the water is returned to the aquifer after use.

The Cheswold aquifer has been used continuously as a source of water at Dover since 1893. With the gradual addition of wells, withdrawals have increased from 0.05 million gallons per day (Mgal/d) in 1893, to 6 Mgal/d in 1973. Data on pumpage from the Cheswold aquifer are unavailable for the period 1893 to 1931. However, the literature suggests that the majority of the early development occurred before 1931. Eastman and Beckett (1931) reported a Cheswold aquifer withdrawal of 0.6 Mgal/d by the City of Dover in 1931. Marine and Rasmussen (1955) presented a brief summary of the development of the Cheswold aquifer by

the City of Dover. In addition to the 1893 well, an 8-inch production well was drilled in 1900. In 1909, two more production wells were screened in the Cheswold aquifer. In 1932, well Jd14-2 (Delaware Geological Survey numbering system), which is still in use, was drilled at the old powerplant site on the St. Jones River. Other wells include Jd14-1 drilled at the Division Street site in 1938 and well Jd24-1 drilled at the Dover Street site in 1948. More recently, the following Cheswold aquifer production wells have been added to the city system: Jd14-6 at Water Street (1952); Jd15-2 at Bayard Avenue (1955); Jd15-4 at the East Dover Elementary School (1964); Jd25-2 at Danner Farm (1964); and Jd14-17 at the Water Treatment Plant (1978).

Several large industries rely on the Cheswold aquifer for water supply; among the largest are a latex manufacturing plant and a poultry dressing plant. Wells at the latex plant (Jd14-11, Jd15-1) were drilled in 1948 and 1953, and the well at the poultry processing plant (Jd14-5) was installed in 1931. Marine and Rasmussen (1955) estimated the 1953 pumpage from these wells to be 1.1 Mgal/d. An estimate of a pre-1952 industrial withdrawal in the Dover area was 0.6 Mgal/d. This estimate was obtained by subtracting the withdrawal of well Jd15-1 at the latex plant from the total 1953 industrial pumpage. The remaining early developers of the Cheswold aquifer are Dover Air Force Base and Delaware State College. Pumpage from wells at these sites in the 1940's was estimated to be 0.5 Mgal/d and 0.05 Mgal/d, respectively.

Although a decline in head of 23 feet was observed in the Dover area between 1939 and 1952 (Marine and Rasmussen, 1955), it appears that the majority of this decline probably occurred prior to the late 1940's. This is implied by the 1950-52 pumpage for the City of Dover reported by Marine and Rasmussen (1955). During this period, Cheswold aquifer pumpage by the City of Dover remained relatively constant at about 1.0 Mgal/d. Total Cheswold aquifer pumpage in the late 1940's and through 1951 has been estimated (Table 2) at 2.15 Mgal/d.

Rapid development of the Cheswold aquifer occurred from 1952 to the late 1960's. Pumpage for 1953 averaged 3.2 Mgal/d and represents an increase of about 1.1 Mgal/d over the estimated pumpage for the late 1940's and early 1950's.

All production wells tapping the Cheswold and Piney Point aquifers prior to 1978 are listed in Table 2 (Appendix II), with average pumping rates for selected periods from pre-1952 to 1977. The selected periods shown are consistent with the time intervals used in the transient simulation and are discussed below.

Figure 6 shows average daily pumpage from the Piney Point and Cheswold aquifers during the period 1952-77. Early data for this plot are based on pumpages reported by Marine and Rasmussen (1955); the period 1957-67 reported by Sundstrom and Pickett (1968); and recent (1968-77) data inventoried during the summer of 1977. Withdrawal from the Piney Point aquifer from 1957 to 1967 was based on estimates reported by Sundstrom and Pickett (1968), and recent pumpage data were based on an inventory of users.

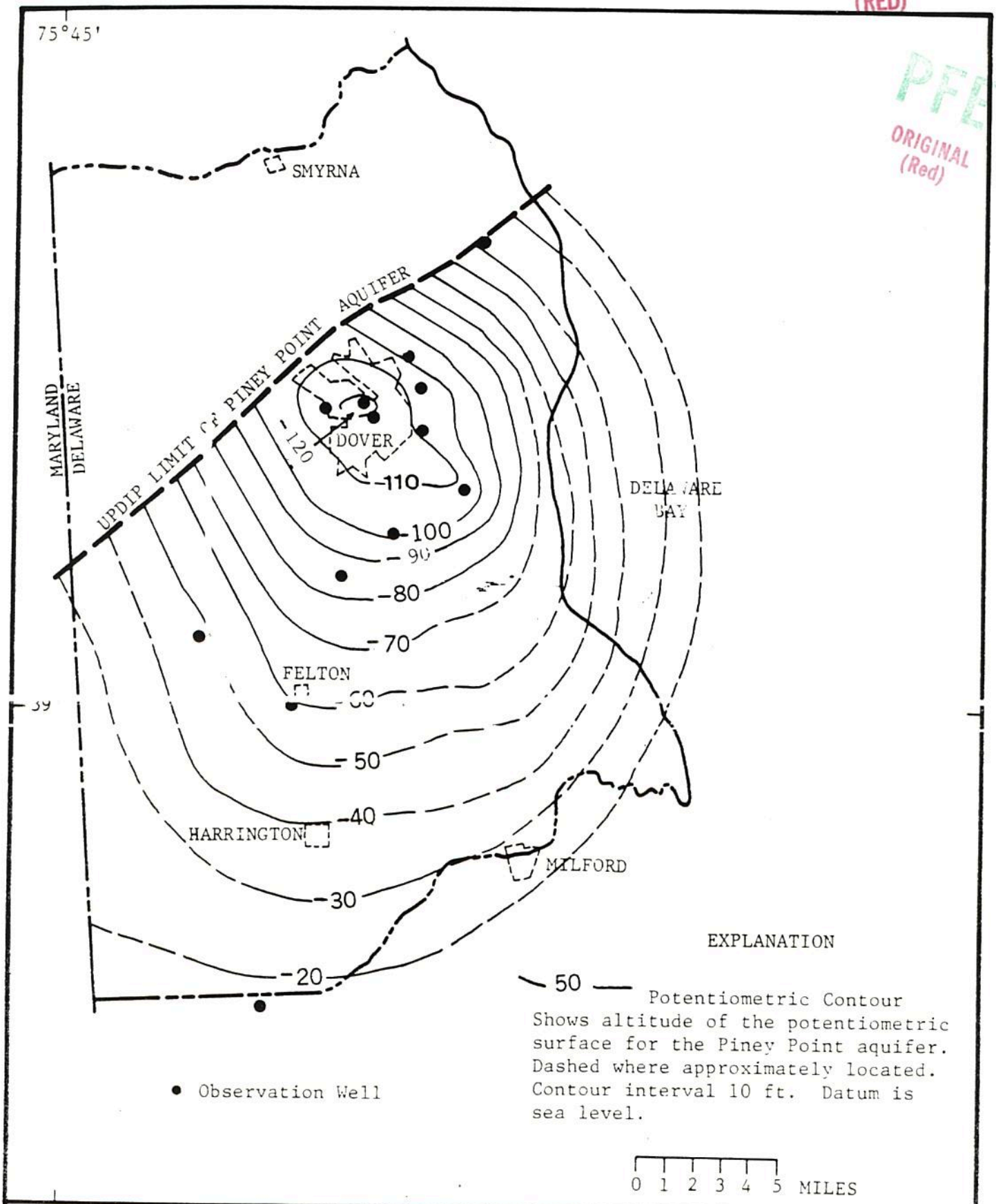


FIGURE 9 - POTENTIOMETRIC SURFACE OF THE PINEY POINT AQUIFER, JUNE 1977.

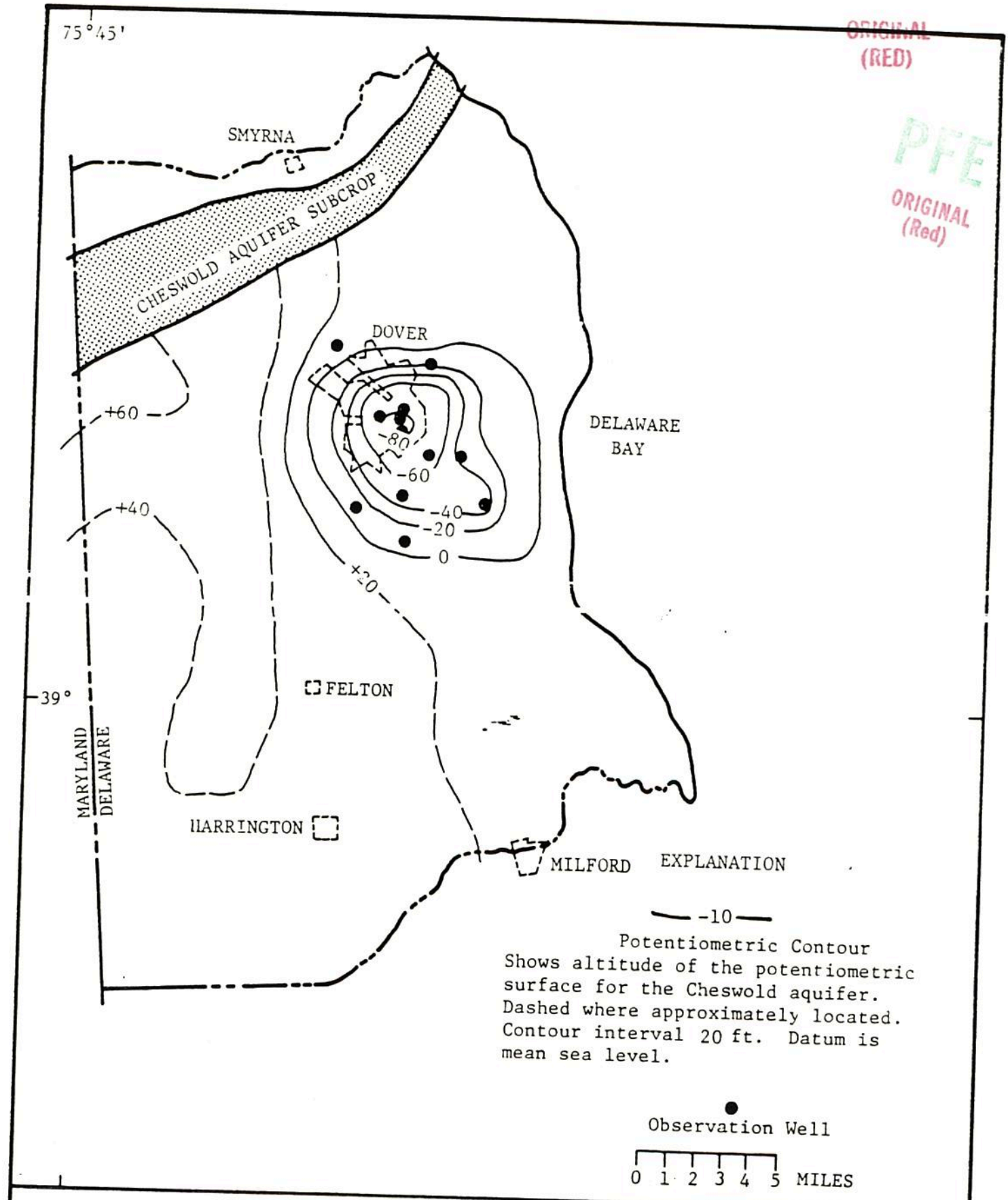


FIGURE 14 - POTENTIOMETRIC SURFACE OF THE CHESWOLD AQUIFER, JUNE 1977.

REFERENCE 3C

INSTALLATION RESTORATION PROGRAM

PHASE I - RECORDS SEARCH

DOVER AFB, DELAWARE

PREPARED FOR

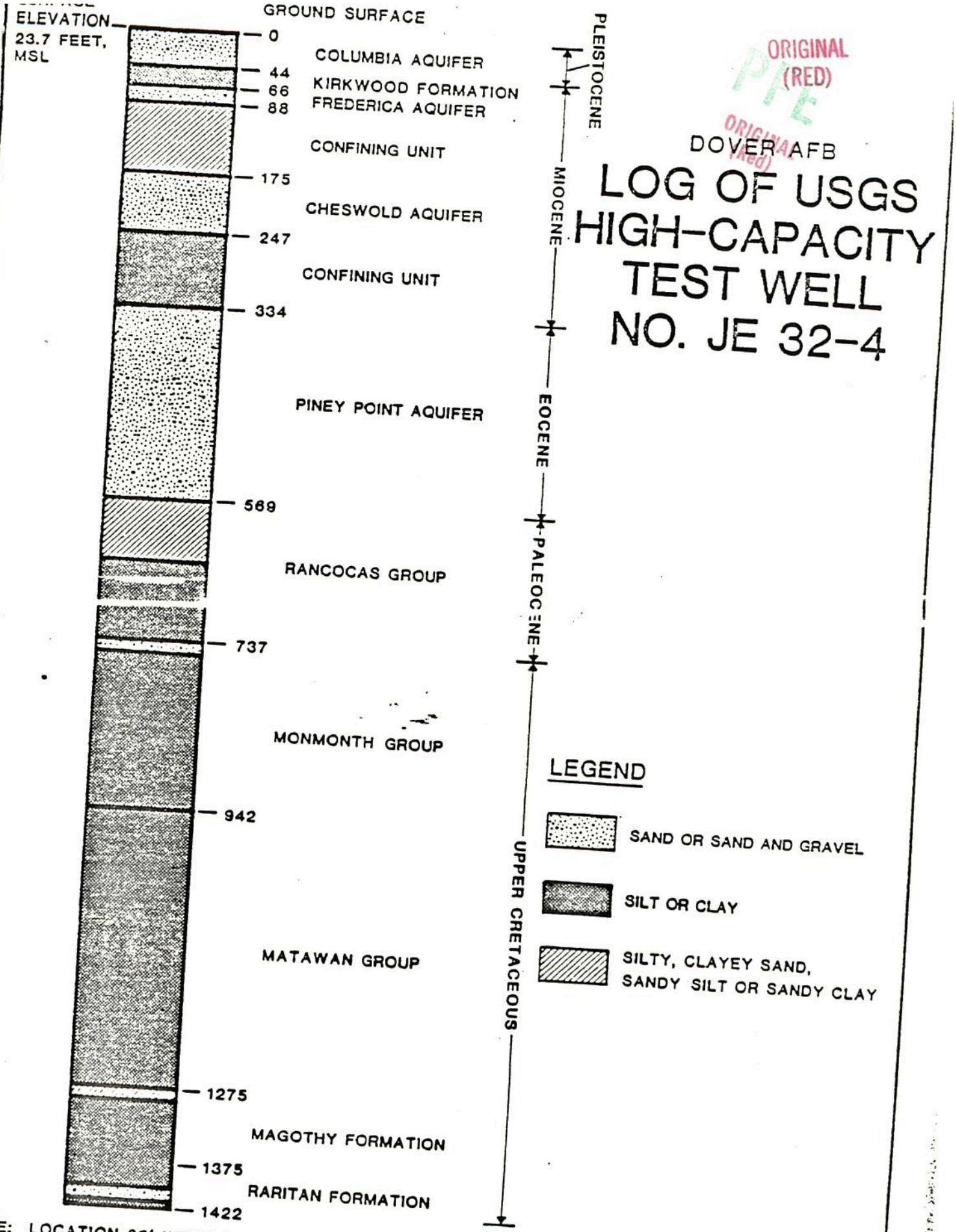
UNITED STATES AIR FORCE
AFESC/DEV
Tyndall AFB, Florida
and
HQ MAC/DEEV
Scott AFB, Illinois

OCTOBER 1983

TABLE 3.2
GEOLOGIC UNITS OF DOVER AIR FORCE BASE

System	Formation	Probable Thickness at Dover AFB	Typical Lithology
Quaternary	Columbia Group	10	Sand, gravel
Tertiary	Chesapeake Group, undivided	210	Medium to coarse sand, silt and clay.
	Piney Point Formation	25	Glauconitic sand, silt, and clay.
	Rancocas Group	108	Glauconitic sand and silt.
Cretaceous	Monmouth Group	205	Silt and clay.
	Matawan Group	333	Fine sand, silt and clay.
	Magothy Formation	90	Sand and silt, interbedded.
	Raritan Formation	574	Variegated clay and sand, interbedded.

Source: Modified from Rasmussen, et. al., 1958.



ORIGINAL (RED)

DOVER AFB

LOG OF USGS HIGH-CAPACITY TEST WELL NO. JE 32-4

NOTE: LOCATION 80' WEST OF STORAGE TANK NO. 611 (FIGURE 3.4)
SOURCE: MODIFIED FROM RASMUSSEN ET. AL., 1958

sand and gravel. At Dover Air Force Base, this unit is some twenty-two feet thick. Because it is not normally utilized as a source of water in the study area, it has not been adequately investigated, therefore, little is known about its specific hydraulic properties in central Kent County. The Frederica subcrop (area where the unit is present immediately below the principal overlying strata) occurs as a narrow band crossing Delaware in the vicinity of Dover, north of Dover Air Force Base. The unit probably derives most of its recharge in this zone. Water is contained in the unit under artesian (confined) conditions and the major flow direction is probably downdip to the southeast with respect to the installation.

Deep Units

The Cheswold and Piney Point Formations form the two primary deep, regional aquifers of the study area. The Cheswold Aquifer, a part of the lower Chesapeake Group, occurs at a depth of some 175 feet below ground surface at Dover air Force Base. It is approximately 111 feet thick at test well JE32-4, and is comprised mainly of noncalcareaus fine to coarse sand, gravel and shells. Prior to extensive development the Cheswold probably was recharged in its subcrop area and to a limited extent by leakage from the overlying Columbia, where the confining layer is somewhat sandy. For the purposes of this discussion, the subcrop of the Cheswold is a narrow belt extending across Delaware, some ten miles northwest of Dover Air Force Base. The Cheswold subcrop is defined as the area or zone where it is in direct hydraulic communication with the unconfined Columbia deposits. Ground-water flow system modeling implies that extensive development has induced recharge to the Cheswold from the 32 square mile area of the St. Jones River basin northwest of the City of Dover (Leahy, 1982). Once water has entered the Cheswold, it flows downdip (southeast) or to the nearest pumping center for withdrawal. Figure 3.8, a potentiometric map of the Cheswold Aquifer, shows ground-water levels and flow directions for the study area. An examination of the potentiometric surface indicates that a major drawdown feature (cone of depression) has been created and is centered over the southeast section of the City of Dover. Cheswold water level elevations indicate that flow within the aquifer has been reversed below Dover Air Force Base and now proceeds west and northwest toward the city (1975 data).

Based upon extrapolation, the hydraulic gradient appears to be on the order of forty feet per mile at the base.

Underlying the Cheswold Aquifer is a significant confining bed of silty, clayey sand, reported to be approximately 100 feet thick at Dover Air Force Base (Leahy, 1979). This confining layer separates the Cheswold from the underlying Piney Point Formation, the deepest aquifer of consequence in the study area. The Piney Point's lithology is reported to be marine fine to coarse sands, shells, glauconitic and calcareous. Pre-development recharge to the aquifer was reported to be by leakage through silty confining units from units above, as the Piney Point neither crops out nor subcrops an overlying aquifer (Leahy, 1979). Additional recharge has probably been induced from the Cheswold Aquifer, in reponse to extensive exploitation of the Piney Point. Figure 3.9 is a potentiometric surface map of the Piney Point Aquifer which has been modified from Leahy (1979). This drawing shows that ground-water flow within the Piney Point proceeds in a northwesterly direction relative to Dover Air Force Base along a gradient estimated to be on the order of twenty feet per mile (1975 data). A major drawdown feature is centered beneath the City of Dover.

Ground-Water Use

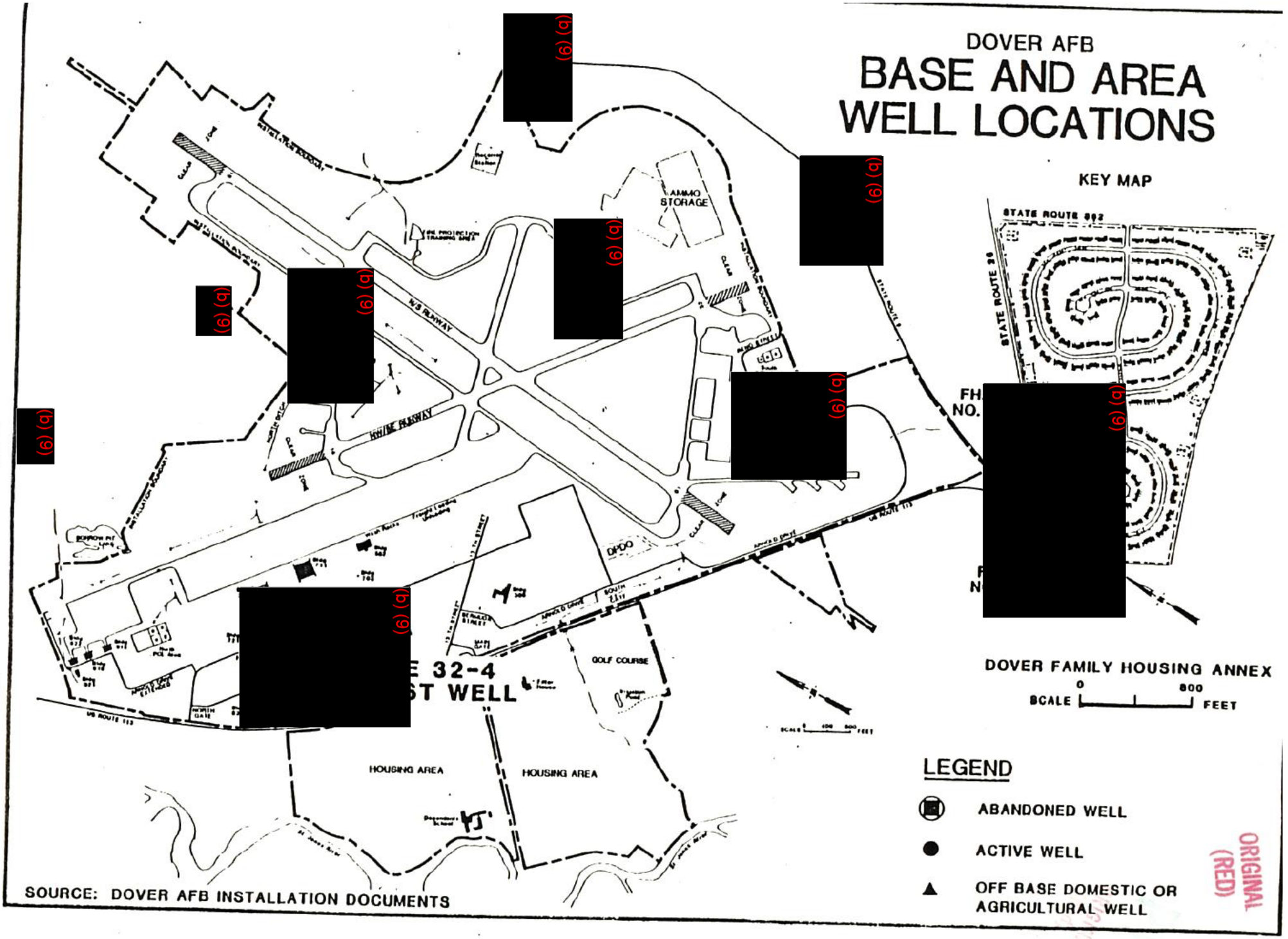
Ground water is utilized by the entire population of the study area. The Columbia is known to furnish water supplies to domestic and agricultural consumers near the installation. While the actual locations of these wells are unconfirmed, it is believed that most permanently inhabited structures near the base possess at least one well finished into the Columbia for the purposes of human consumption, stock watering or crop irrigation. Due to its general accessibility, reliability (does not run dry) and typical good quality (Woodruff, 1970), the Columbia is known to be a good source of potable supplies. At present, a consultant is examining the utility of the Columbia Aquifer as a potential future source of additional water supplies for the City of Dover. It has been reported that if the Columbia is developed by the city, new well fields would be constructed immediately west and north of Dover Air Force Base (Hodges, 1983). The primary limitation of the Columbia is its easy susceptability to contamination.

TABLE 3.4
DOVER AIR FORCE BASE
INSTALLATION WELL CONSTRUCTION INFORMATION

Well Identifier	Location (Bldg)	Depth (Feet)	Screen Length (Feet)	Diam. (In.)	Aquifer	Static Water Level (Ft. Below Surface)	Capacity (GPM)	Construc. Date (Reconst. Date)
A	606	268	30	10	Cheswold	-	300	1952
B	641	230	45	10	Cheswold	68	700	1953 (1975)
C	645	233	30	10	Cheswold	81	675	1955 (1974)
D	612	560	100	12	Piney Point	126	900	1963 (1973)
*FH4 No. 1	4000	697	50	12	Piney Point	98	620	-
*FH4 No. 2	4200	-	-	-	Piney Point	-	-	1979
NEW	1326	560	-	12	Piney Point	120	200	1983

Source: Installation Documents (1978) and Sundstrom and Pickett (1968)

* Indicates Family Housing Annex


DOVER AFB
BASE AND AREA
WELL LOCATIONS
KEY MAP
STATE ROUTE 9
STATE ROUTE 2
AMMO STORAGE
N/S RUNWAY
E/W RUNWAY
DRMO
GOLF COURSE
HOUSING AREA
HOUSING AREA
DOVER FAMILY HOUSING ANNEX
SCALE 0 800 FEET
LEGEND
ABANDONED WELL
ACTIVE WELL
OFF BASE DOMESTIC OR AGRICULTURAL WELL
SOURCE: DOVER AFB INSTALLATION DOCUMENTS
ORIGINAL (RED)